Proceedings of RIKEN BNL Research Center Workshop

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Formal Report
Volume 54

RHIC Spin Collaboration Meetings XVII, XVIII, & XIX

June 20, 2003
June 30, 2003
August 18, 2003

Organizer:

Brendan Fox

RIKEN BNL Research Center

Building 510A, Brookhaven National Laboratory, Upton, NY 11973-5000, USA

Preface to the Series

The RIKEN BNL Research Center (RBRC) was established in April 1997 at Brookhaven National Laboratory. It is funded by the "Rikagaku Kenkyusho" (RIKEN, The Institute of Physical and Chemical Research) of Japan. The Center is dedicated to the study of strong interactions, including spin physics, lattice QCD, and RHIC physics through the nurturing of a new generation of young physicists.

During the first year, the Center had only a Theory Group. In the second year, an Experimental Group was also established at the Center. At present, there are seven Fellows and seven Research Associates in these two groups. During the third year, we started a new Tenure Track Strong Interaction Theory RHIC Physics Fellow Program, with six positions in the first academic year, 1999-2000. This program had increased to include ten theorists and one experimentalist in academic year, 2001-2002. With recent graduations, the program presently has eight theorists and two experimentalists. Beginning last year a new RIKEN Spin Program (RSP) category was implemented at RBRC, presently comprising four RSP Researchers and five RSP Research Associates. In addition, RBRC has four RBRC Young Researchers.

The Center also has an active workshop program on strong interaction physics with each workshop focused on a specific physics problem. Each workshop speaker is encouraged to select a few of the most important transparencies from his or her presentation, accompanied by a page of explanation. This material is collected at the end of the workshop by the organizer to form proceedings, which can therefore be available within a short time. To date there are fifty-four proceeding volumes available.

The construction of a 0.6 teraflops parallel processor, dedicated to lattice QCD, begun at the Center on February 19, 1998, was completed on August 28, 1998. A 10 teraflops QCDOC computer in under development and expected to be completed in JFY 2003.

T. D. Lee
November 22, 2002

*Work performed under the auspices of U.S.D.O.E. Contract No. DE-AC02-98CH10886.

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Summary from RHIC Spin meeting of June 20, 2003
by Gerry Bunce

The meeting was organized by Brendan Fox, and the focus was on getting information to develop a spin run plan for Run 4, to bring to collaborations.

Polarized gas jet target: great progress described by Yousef Makdisi
- -- expected to be ready for Run 4 (to be installed in summer/fall, then removed during gold-gold run, to work in lab; installation then takes 3 days for a pp run)
- -- 1 development silicon detector of 4 works from 1st batch (reported by Sandro Bravar), looking at other existing silicon of similar size from Hamamatsu (expected 50% to work, also issue of schedule for production from BNL Instrumentation)

STAR spin (Les Bland): machine development and physics for Run 4
- -- this is only from the spin group. STAR has not started discussions on the beam use proposal yet
- -- *machine development--toward spin goal of 30 pb^-1/week, P=0.7*
- -- goal for Run 4 P^4 x LT > 10 nb^-1/week (10x run 3)
  - -- 3/4 barrel EmCal, 3 pb^-1, P=.4
  - -- physics for A_LL, jets==>gluon polarization
- -- polarized gas jet ==> commission, Delta P/P to +/-10%
- -- STAR multi-year plan in the 02 beam use proposal was:
  - -- Au-Au 19 weeks (16 weeks at root(s_NN)=200, 1 at 3 lower energies)
  - -- pp 8 weeks, root(s)=200
- -- important to develop credible plan on luminosity and P, leading to direct photon program
- -- root(s)=500 running requires large LT to be useful, reference data for heavy ions important

PHENIX spin (Yuji Goto): main discussion next week after info from here
- -- Run 3 gave 350 nb^-1, P=.27, P^4 x LT = 1.8 nb^-1
  - -- expectation on A_LL 2-3 sigma from max. gluon model
    - -- vs. 3 pb^-1, P=.4 (about 20 sigma from max. gluon pol.) (Run 2 plan)
    - -- Run 2 plan would give 20K direct photons, p_T>5, 10K J/psi, 1M single e, 4K mu-mu and 7K e-mu charm events.
  - -- root(s)=500 (discussed for run 6, vs. 200 GeV)
    - -- compared xdelta(Delta g) for 200, 500 GeV--200 GeV better

BRAHMS spin (Brendan Fox):
- -- Run 4 would place spectrometer at 2.3 deg., get interesting measurement in 20-40 hours.

RHIC summary (Haixin Huang):
- -- source problem early in run (ok for Run 4?)
- -- pp started March 26
- -- yellow snake failure, partial snake solution saved run
- -- physics started May 3
- -- STAR rotator commissioning May 15
- -- switch to 2 IRs May 23
- -- run ended May 30 (9 weeks total)

AGS (Leif Ahrens):
- -- expected to reach P=.5, reached above .4
- -- intensity dependence of P not resolved (but see Mei Bei plot)
- -- lower P at end of run--not understood yet
- -- plan to use thinner stripping foil (half) into Booster to reduce emittance for Run 4
- -- warm snake for Run 4 (but no plan to correct weak intrinsics--issue of manpower, and small emittance improves pol. losses for these resonances
- -- cold snake for Run 5

Q: why 2 steps?--if cold snake necessary, what do we learn from warm snake?
A: warm snake for spin matching (but then commissioning useful in Run 4?), also problem seems to be strong intrinsic resonances-->replace rf dipole with cold snake (Thomas).

RHIC polarization (Mei Bei):
- -- Mei shows much lower avg. P than we use--probably not throwing out low P runs (aborted store for low P)
- -- no correlation between P and intensity at 24 GeV in RHIC
- -- snake resonance curves--after correction, yellow (with partial snake) still had larger strength than blue (discussion about optimization for yellow done at 24 GeV after recovery from snake failure; may have been off of optimum at 100 GeV)
- -- 20% loss in Delta P/P at end of beta squeeze--coupling problem, plan to squeeze during energy ramp for Run 4, stay on histeresis curve

500 GeV issues--what is possible? (Thomas Roser):
- -- spin resonances 2-3x stronger between 100-250 GeV, orbit corrections imply that we preserve P, but tight tolerances on corrections
- -- other issues all same as for 200 GeV--i.e. need to be solved first

Plan (Thomas Roser):
- -- considering changing working point (fractional tune, related to both beam resonance space and spin resonance space)--to improve beam-beam tune spread and shift issues. Presently about .22 to .23, change to .18? This was the original plan, but early running had problems at this tune.
- -- tune feedback required to be operational--worked in Run 3, but not operational (delta tune to <.005 with feedback, 10x larger without (check))
- -- introduced letter from Wolfram Fisher and Thomas Roser on expected performance for Run 4

Polarized Jet Target Status

Y. Makdisi, BNL

June 20, 2003

for
RHIC Spin Collaboration Meeting XVII
RIKEN BNL Research Center

Polarized Jet target status

The overall view

The Dissociator stage

The Atomic Beam stage

The RF transitions status

The Breit Rabi polarimeter

The 12 o'clock area

Where do we go from here?

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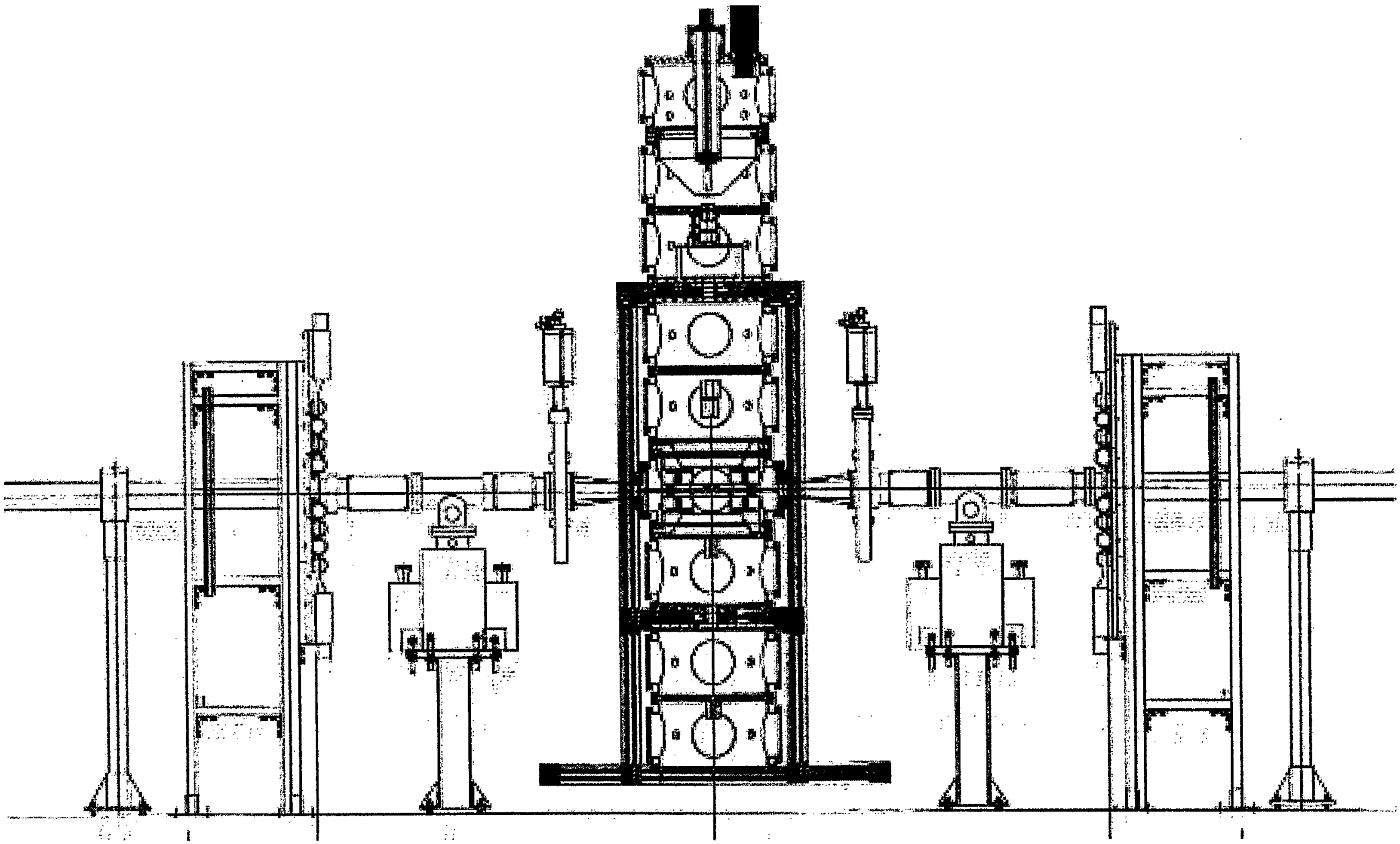
Yousef I. Makdisi
DIS03
St. Petersburg April 24,2003

The overall system



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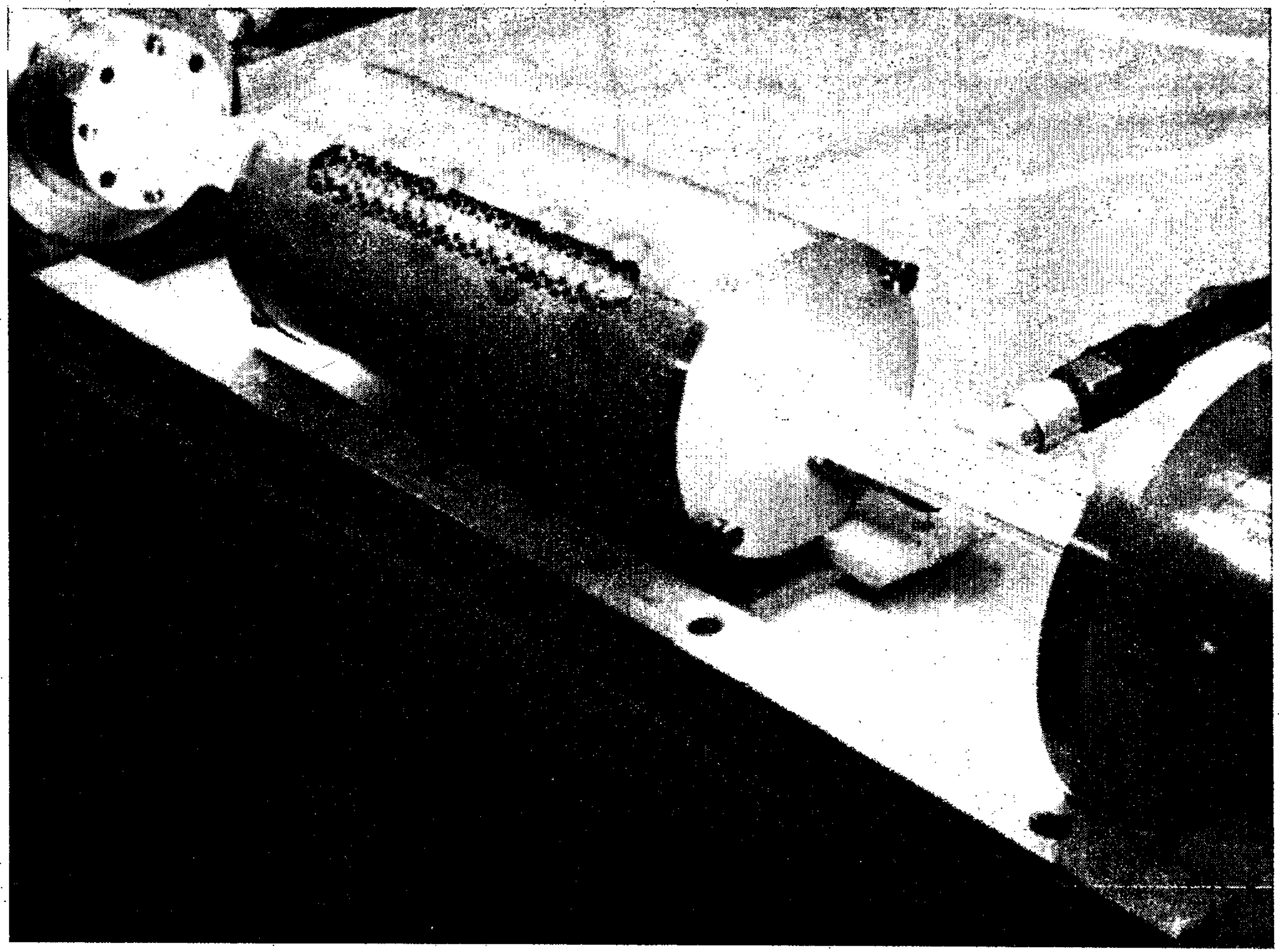
The glow on the test bench



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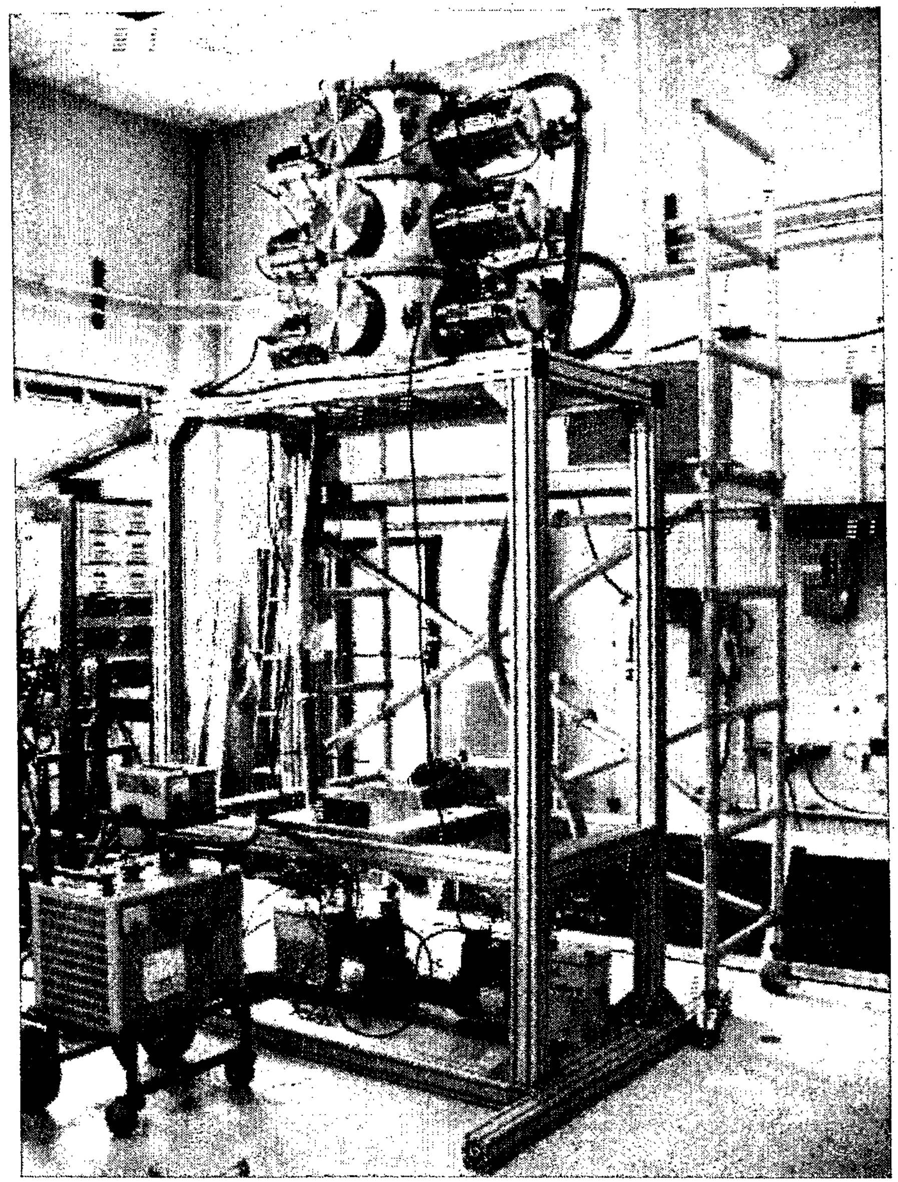
Hydrogen dissociation using a variable frequency and power source

The dissociator stage

The first test of the pumping system. After fixing a few leaks, we reached few x 10^{-8} in about two hours.



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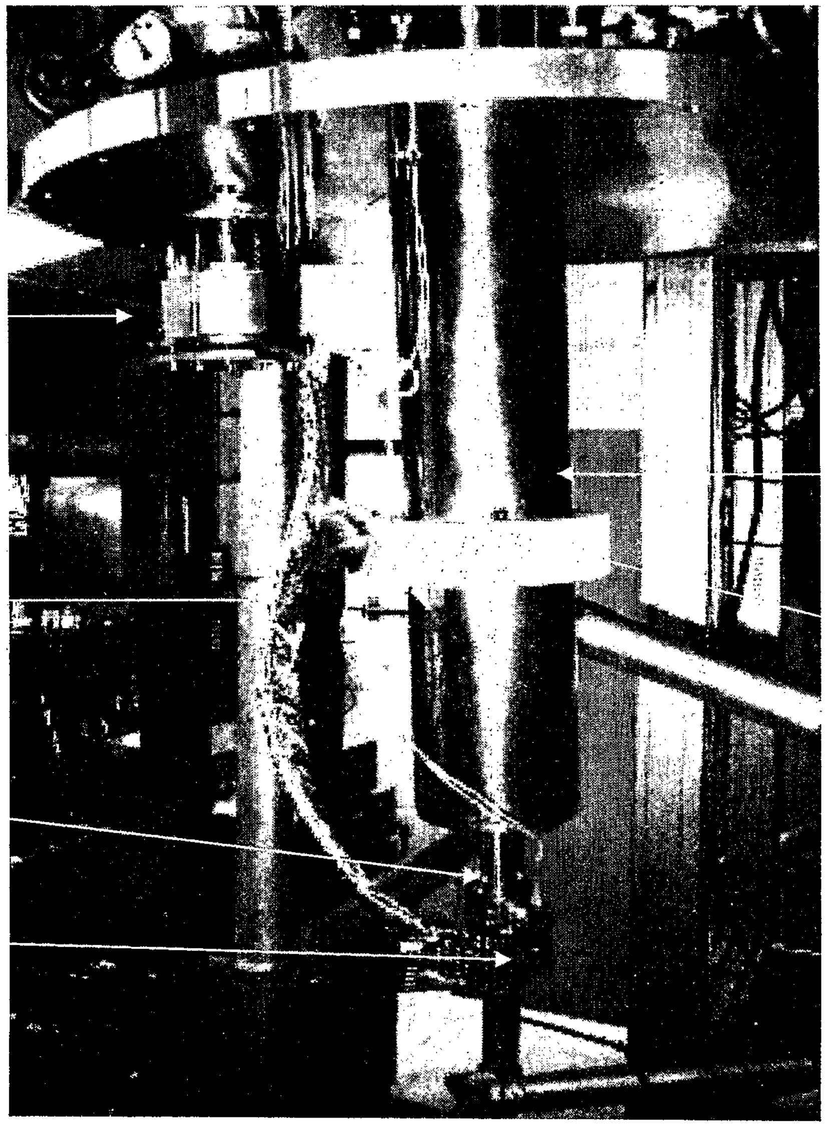
The Dissociator

The cold head
about 20 ° K

The copper strap
transfer to the nozzle

The neck at 80 ° K

The nozzle at 40 ° K



RF system
inside

Alignment

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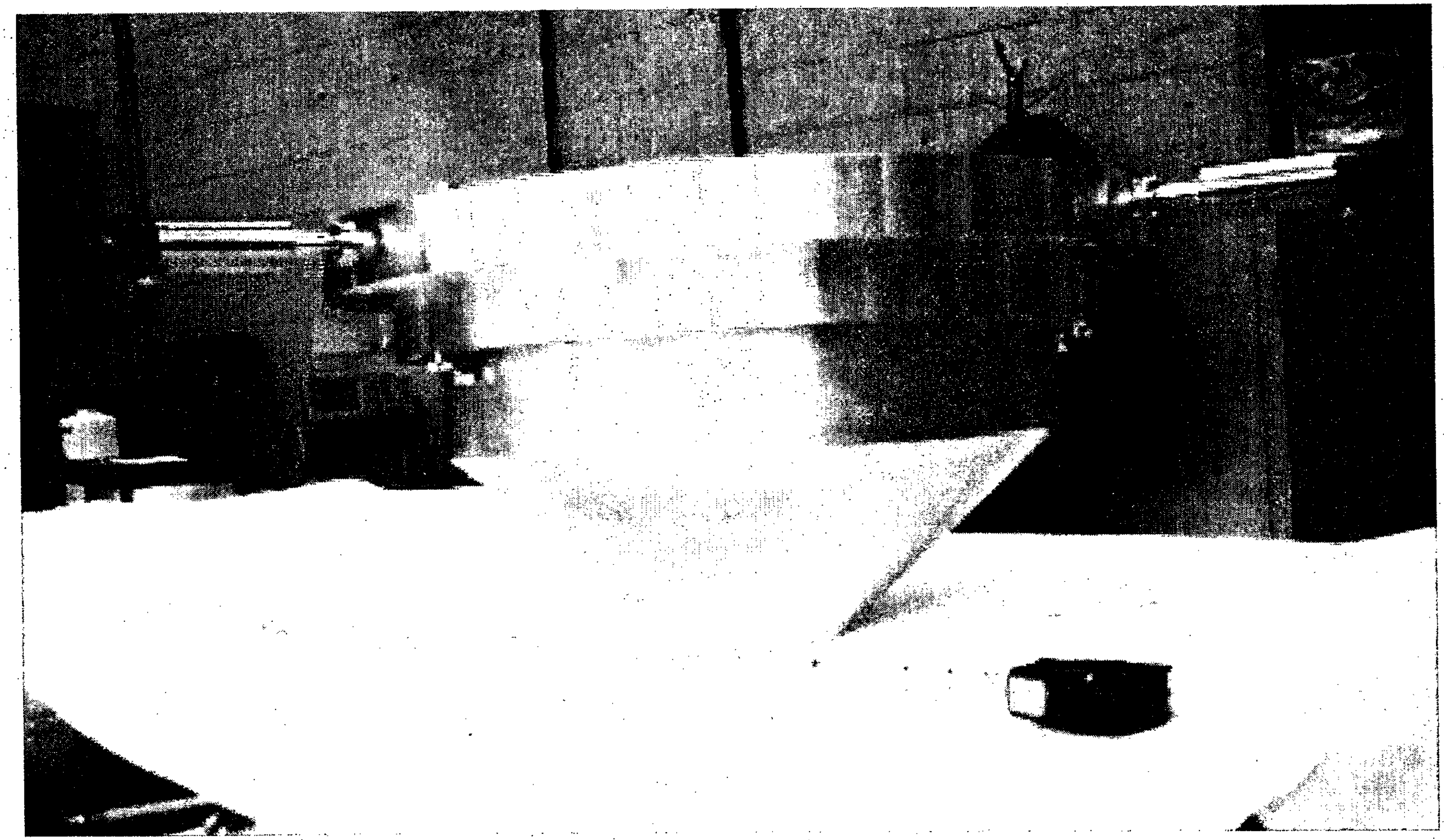
The baffle



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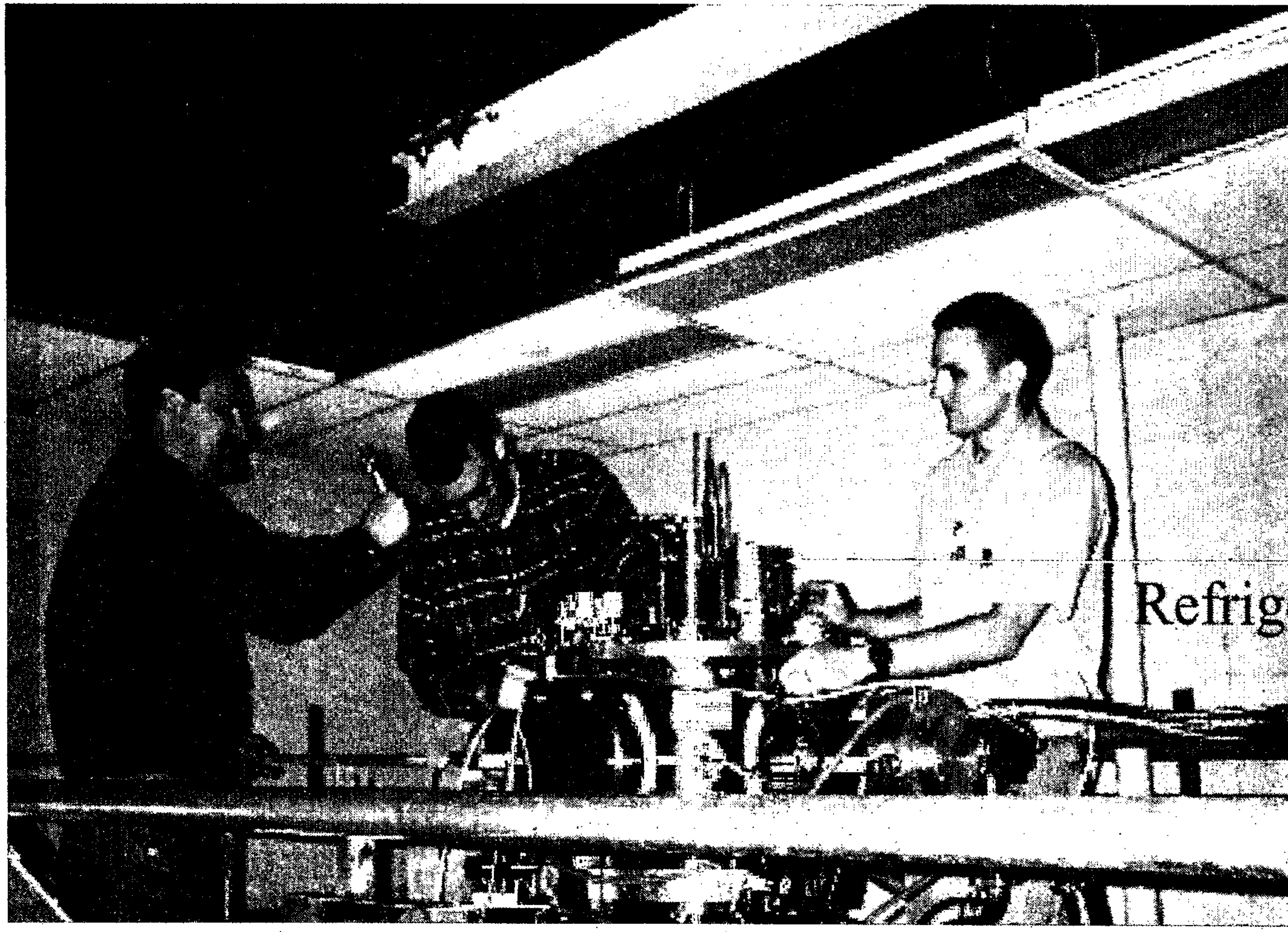
The baffle for differential pumping.
Baffle moving mechanism

Dissociator stage assembled



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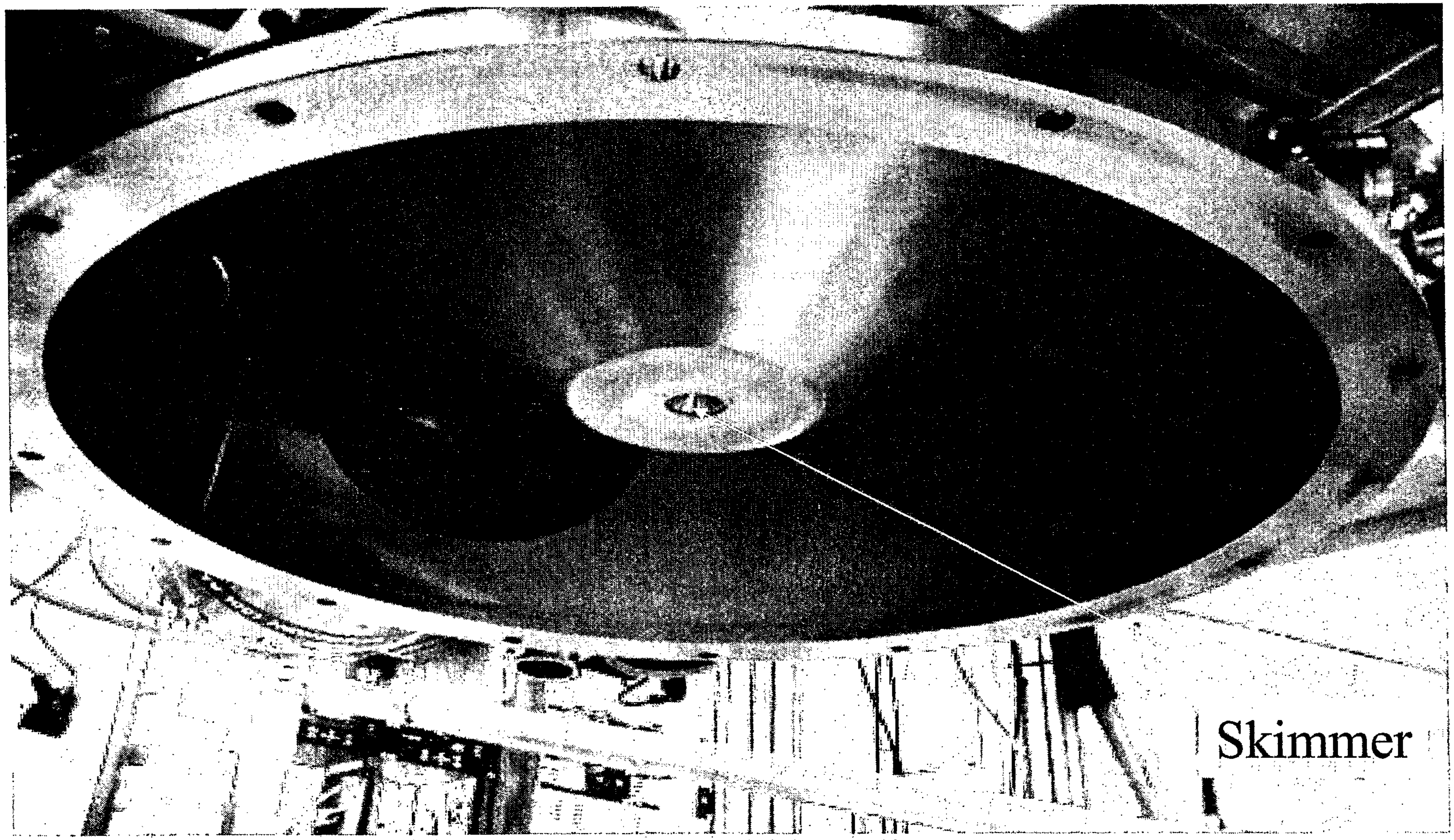
The next step



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First Measurements

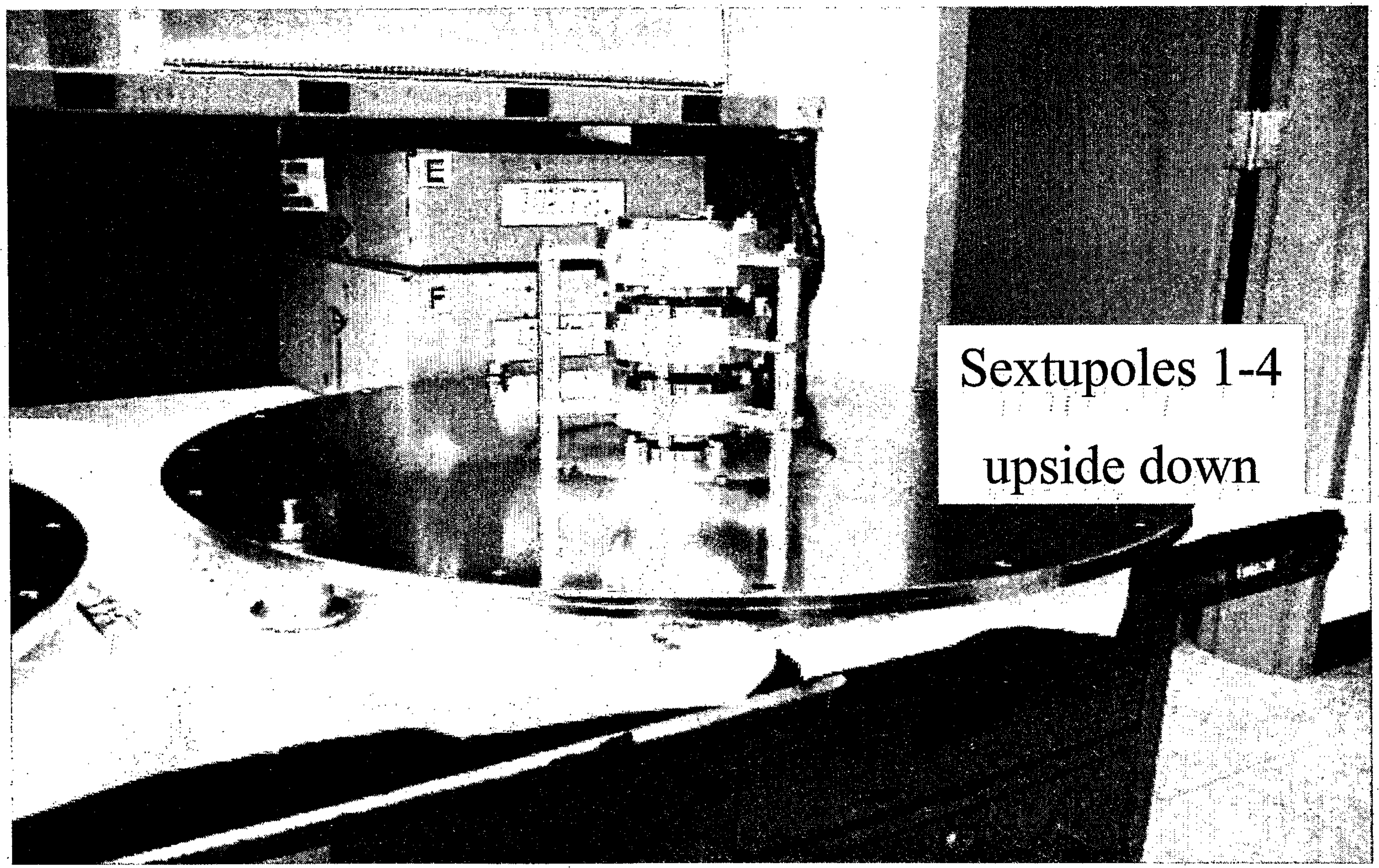
- With a hydrogen beam, we measured vacuum systems at three stages. The dissociator section, after the baffle, and the stage below. The pumping system is working quite well. The levels were better than calculated.

- We added a collimator to mimic the first magnet aperture. With a quadrupole mass analyzer we measured the degree of dissociation and background. Encouraging results were seen.

- This must have been beginners luck as we could not easily repeat the measurement. We suspect that some freezing and blocking occurred at the nozzle.

- Since then we changed the nozzle tip for better transmission. No new measurements with the new set up as the system was opened to install the ABS magets.

The beginning of the ABS stage



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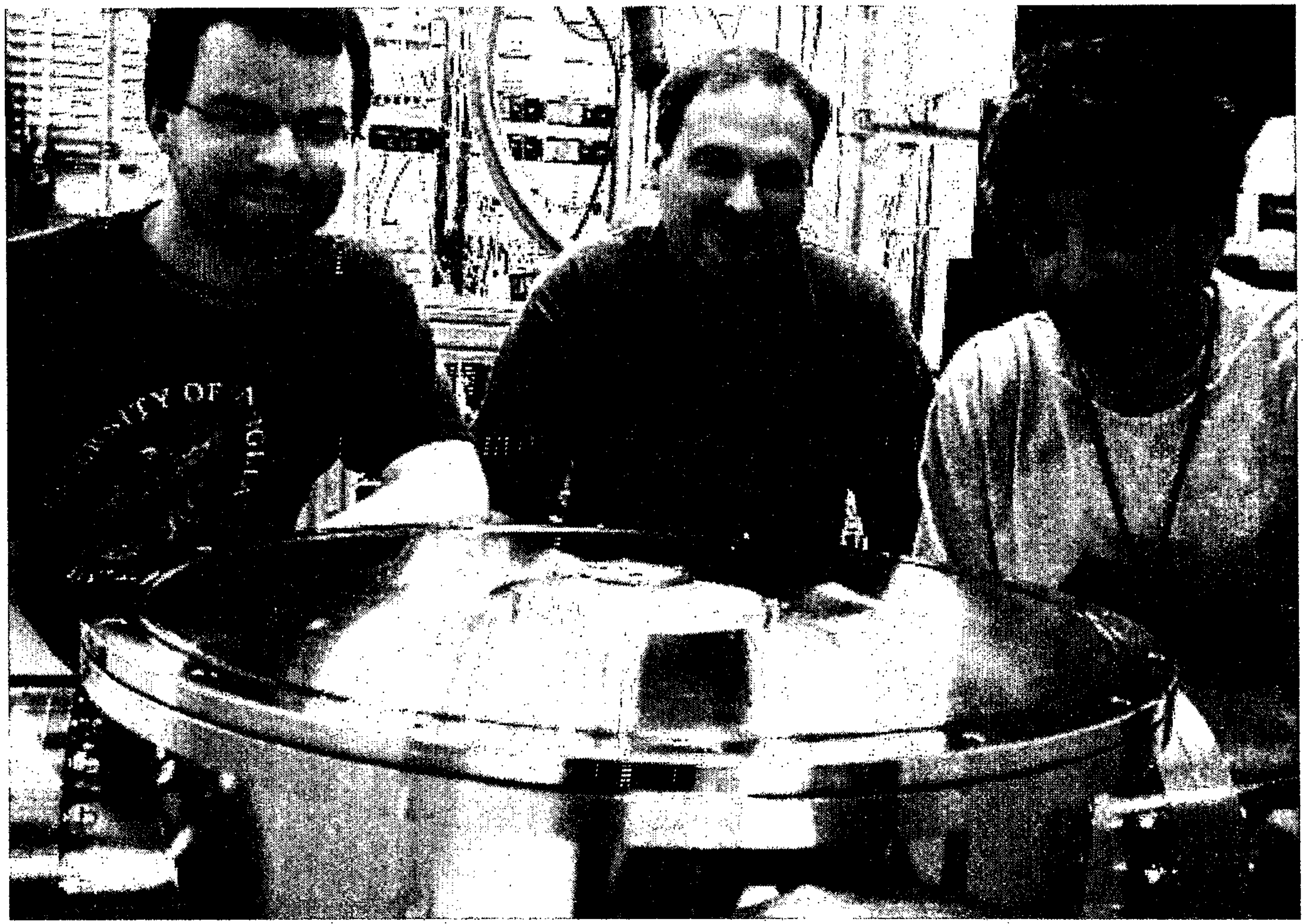
Fields measured by P. Wanderer et al.
Few % lower than requested.

Next in the sequence



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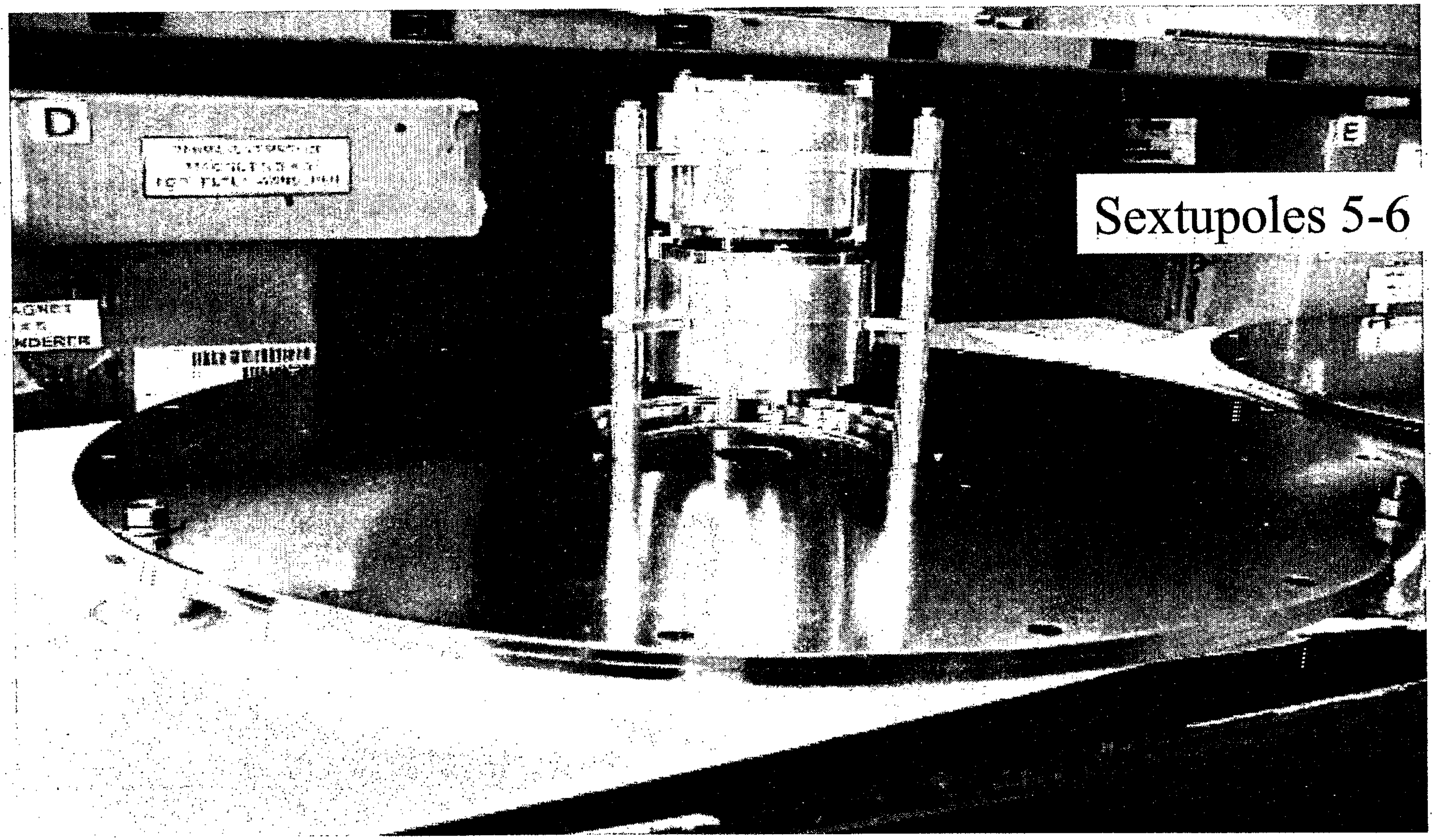
Sextupoles 1-4 mounted
on the vacuum vessel

The next set of magnets



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Fields also low by a few percent

The ABS stage without RF transitions

- Assemble both sets of magnets into the vacuum vessels. Align the nozzle, skimmer, and the first set of magnets. Set the distances from the nozzle to the magnet to the 60 mm value in the simulations. Set the baffle distance.

- Add one dummy vessel with pumping and a profile the profile measuring device as well as a removable 9 mm aperture.

- Add a chamber below equipped with the quadrupole mass spectrometer and its chopper.

- Measure the atomic beam profile with and without and without the 9 mm aperture. (next week)

- Measure the degree of dissociation (H / H2 ratio) versus several dissociator settings. (next two weeks)

The Holding Field Magnet

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The holding Field Magnet

- The Magnet coils are wound

- After some rework an acceptable magnet vacuum vessel was delivered by our machine shops.

- The coils positioning and epoxy potting inside the vessels is underway.

- The next step is to measure the field for uniformity (few x 10^{-3}) in a cylinder of 1 cm diameter and +/- 3 cm long.

- Measure the field along the recoil arms and adjust the two coil currents. (the next couple of weeks)

- Wuzheng found an acceptable magnetic shielding solution for the RF cavities

The magnet is not needed till we get the RF transitions in place

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The RF Transitions

Wisconsin work

- The transitions have been designed.
- The RF cavities have been built and tested (3 out of 4)
- The strong and weak magnets are being wound
- The bipolar power supplies have been chosen and an order is being placed
- The Shielding pieces are in the process of machining
- Anticipate delivery to BNL the 2nd week of July
- With these in place we need to measure the magnetic field adiabiticity and zero crossing.

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The Breit Rabi Polarimeter

Wisconsin Work

- The chopper has been built and the operation tested at 10Hz

- The naked ion gauge has been procured

- The assembly hardware is built and delivered to BNL

- The hardware has been mounted on its flange awaiting installation on the jet

- Sextupole magnets 7 and 8 mounting, design and construction is underway as is the beam blocking system

- This is needed after the RF transitions and holding field magnet are installed

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The electronics racks

- The racks contents have been determined (seven racks are needed)

- The inter rack connections have been mapped out. Wiring and termination on the jet started. This will continue in situ.

- The controls, monitoring and jet DAQ systems (VME stuff) have been purchased

- Anticipate to move the racks to the jet lab late next week to begin assembly of the pieces as they are needed (start with turbo pump power supplies and vacuum controls)

- The PLC has been procured and interlock programming is well underway.

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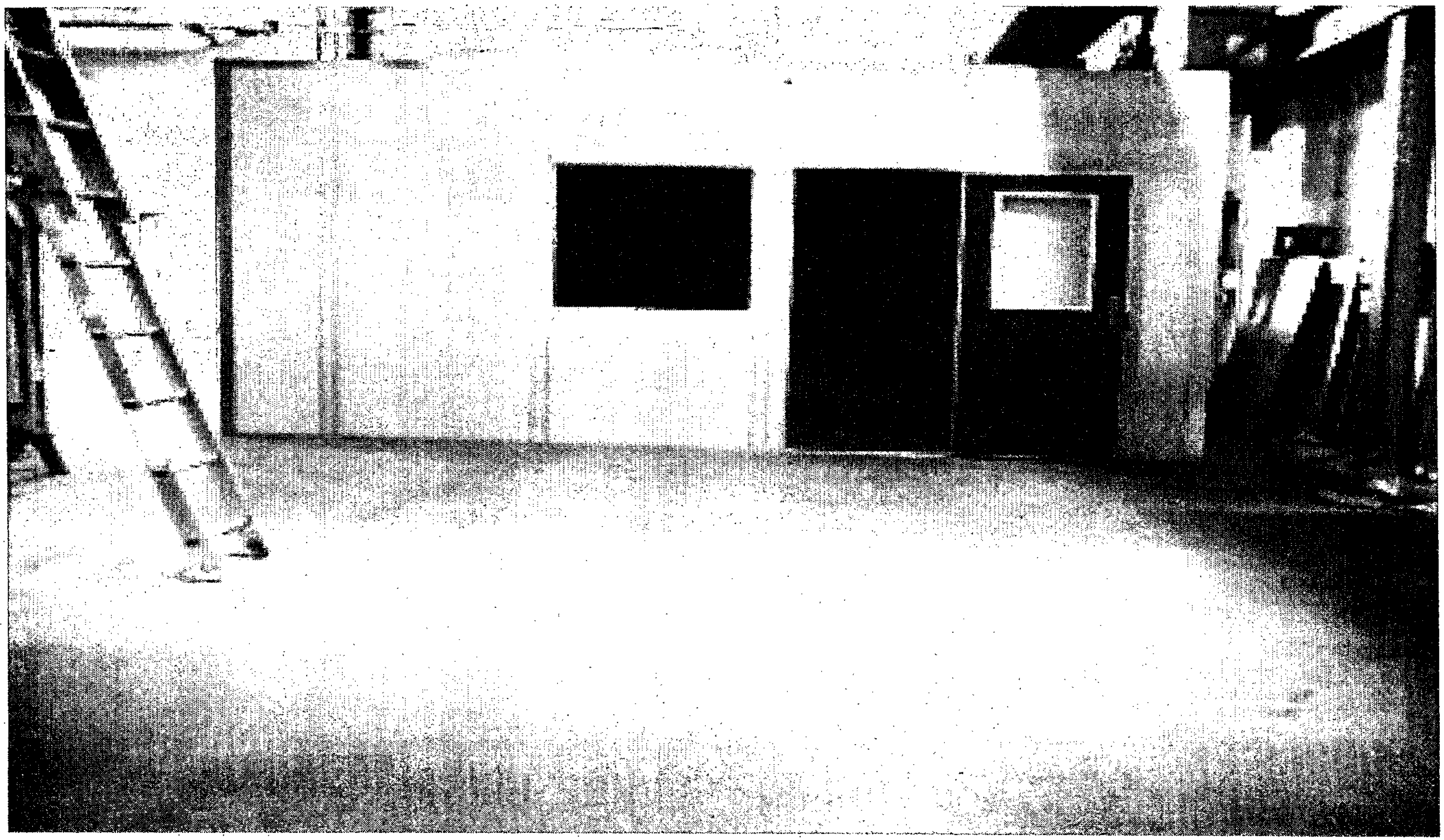
The Counting House at 12 o'clock



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Work in the 12 o'clock area

- The counting house is up. The same crew will install a concrete pad for the transformers and water systems. The same crew will take on the ring entry door modifications.

- The electrical work will start soon on the house as well as the cable trays

- The AC (2 ton) split unit will be ordered and installed soon

- The penetration contract is with plant engineering. Hope to start early July

- The PASS safety system modifications order was placed and hardware (iris scanner, video camera etc.) should be in house soon

- The vacuum group has the ion pumps and isolation valves and spool piece. Beam line modification will be done well in advance of the jet installation.
- The IR crane work has been simplified significantly to limit modifications

Where do we go from here?

- Overall: good progress but we are approximately a month behind compared to our "best laid out" plans prepared last January.

- Assemble and run the jet as a system in the jet lab this summer

- Complete the construction in the IR by early September

- Move the jet into the IR in Mid to late September

- Run the Jet with remote systems in October

- Remove the jet to the lab in late October

- Restore the beam line for HI running by mid November

- Fine tune the Jet through April of 04 prior to reinstallation in RHIC

The Overall RHIC Spin Program

Year		Acceleration/ Polarimetry	P	Weeks Commiss./	root(s)	LT	Physics
2002		RHIC Snakes, CNI Polarimeters	20%	8 (5/3)	200 GeV	1/3 pb^-1	Transverse spin, systematic studies, start learning curve
2003		Spin Rotators, AGS CNI Polarim.	40%	8 (5/3)	200 GeV	6 pb^-1	A(LL), A(N), A(NN) STAR, PHENIX Gluon polarization? A(N),A(NN): pp2pp, BRAHMS
2004		Polarized Jet-- Absolute Polariz.	50%	8 (1/4)	200 GeV	80 pb^-1	Gluon polarization with jets Direct photon?
				(2/1)	500 GeV	20 pb^-1?	Parity violating W+?
2005		AGS Strong Snake	70%	10 (1/7)	200 GeV	140 pb^-1	Gluon polarization with direct gamma
				(1/2)	500 GeV	100 pb^-1	Begin W: antiquark pol.
2006			70%	10 (1/5)	200 GeV	100 pb^-1	Gluon pol.--direct gamma
				(1/3)	500 GeV	150 pb^-1	W parity violation
2007			70%	10 (1/9)	500 GeV	450 pb^-1	W parity violation

Goals: 70% polarization, L = 2 x 10^32 cm^-2 s^-1 (root(s) = 500 GeV)

LT = 320 pb^-1 for root(s) = 200 GeV   LT = 800 pb^-1 for root(s) = 500 GeV

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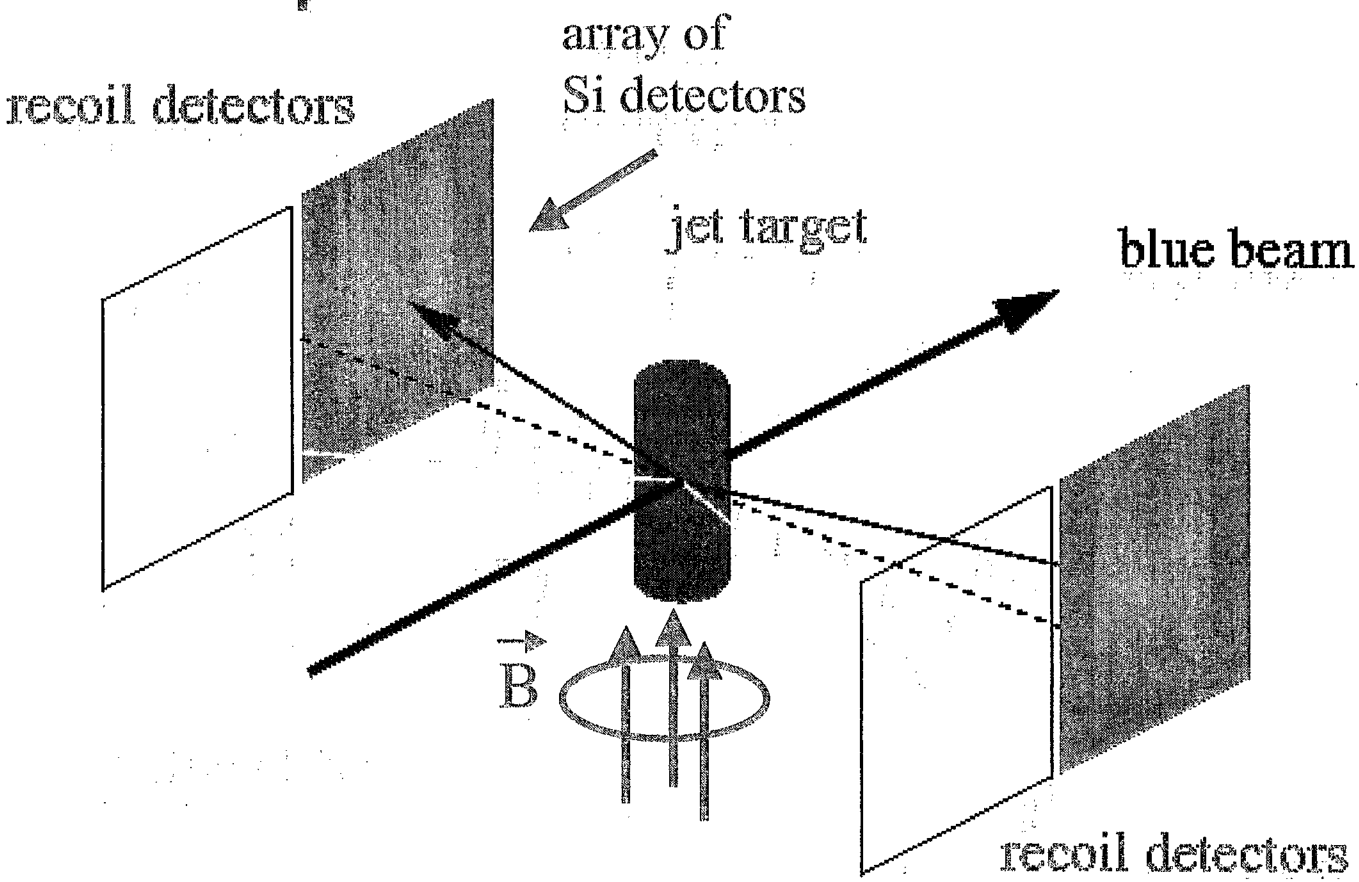
Status of the Jet Target Experiment

A. Bravar, BNL
June 20, 2003

for
RHIC Spin Collaboration Meeting XVII
RIKEN BNL Research Center

Setup



jet target located at intersection point (12 o'clock); yellow and blue beams separated by ~10 mm; only one beam at the time interacts with the jet target

energy $\rightarrow t$

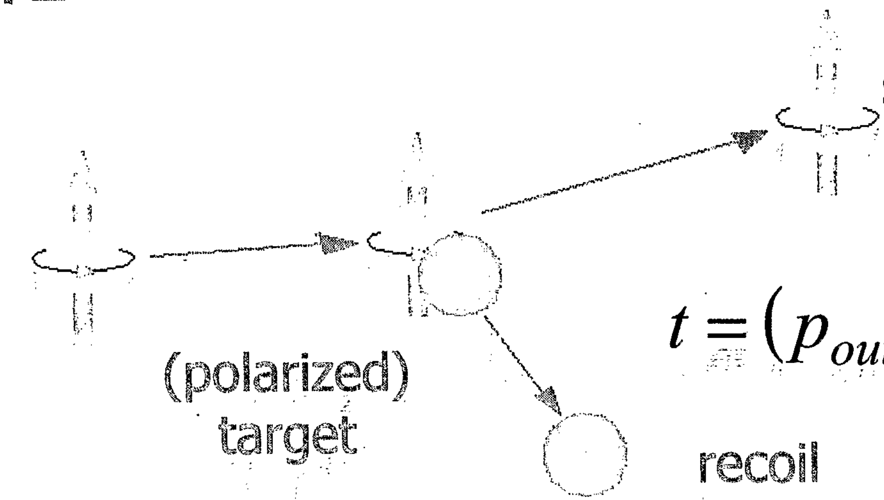
position $\rightarrow \vartheta_R , \varphi_R$

time

readout: Wave Form Digitizers

$\Rightarrow$ *offline* ADC & const. frac. TDC

Principle



$$t = (p_{out} - p_{in})^2 < 0$$

29.

$$A_N(t) = \frac{1}{P_{target}} \cdot \frac{d\sigma(\varphi+\pi)/d\varphi - d\sigma(\varphi)/d\varphi}{d\sigma(\varphi+\pi)/d\varphi + d\sigma(\varphi)/d\varphi}$$

$$P_{beam} = \frac{1}{A_N} \frac{N_{left} - N_{right}}{N_{left} + N_{right}}$$

$A_N^{beam}(t) = A_N^{target}(t)$

for elastic scattering only!

The Road to P_{beam}

Requires several independent measurements

0 target polarization P_{target} (Breit-Rabi polarimeter)

1 A_N for elastic *pp* in CNI region: $A_N = 1 / P_{target}\ \varepsilon_N'$

2 $P_{beam} = 1 / A_N\ \varepsilon_N''$

1 & 2 can be combined in a single measurement: $P_{beam} / P_{target} = - \varepsilon_N' / \varepsilon_N''$

3 CALIBRATION: A_N^{pC} for *pC* CNI polarimeter in detector kinematical range:

$A_N^{pC} = 1 / P_{beam}\ \varepsilon_N'''$

(1 +) 2 + 3 measured simultaneously with several insertions of carbon target

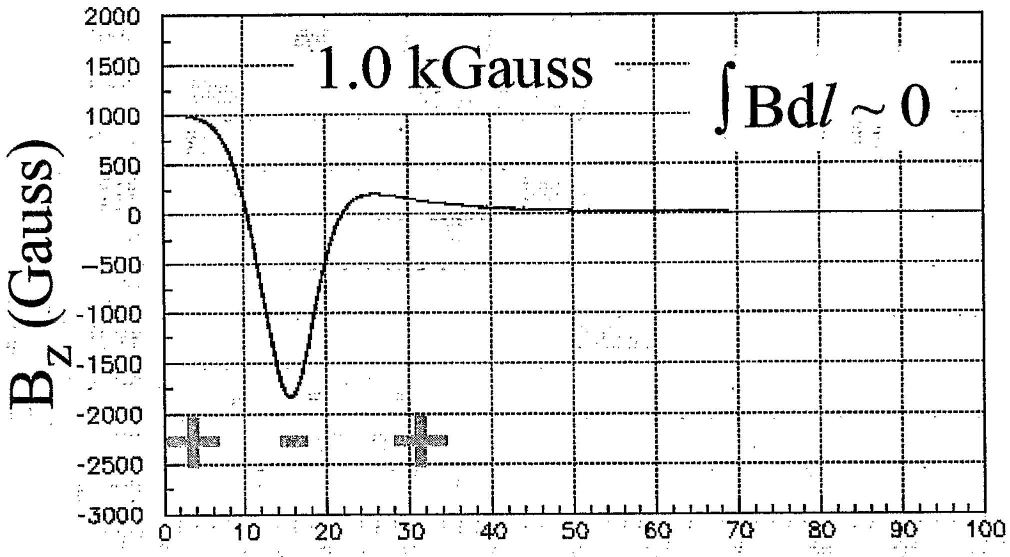
4 BEAM POLARIZATION: $P_{beam} = 1 / A_N^{pC}\ \varepsilon_N''''$ to experiments

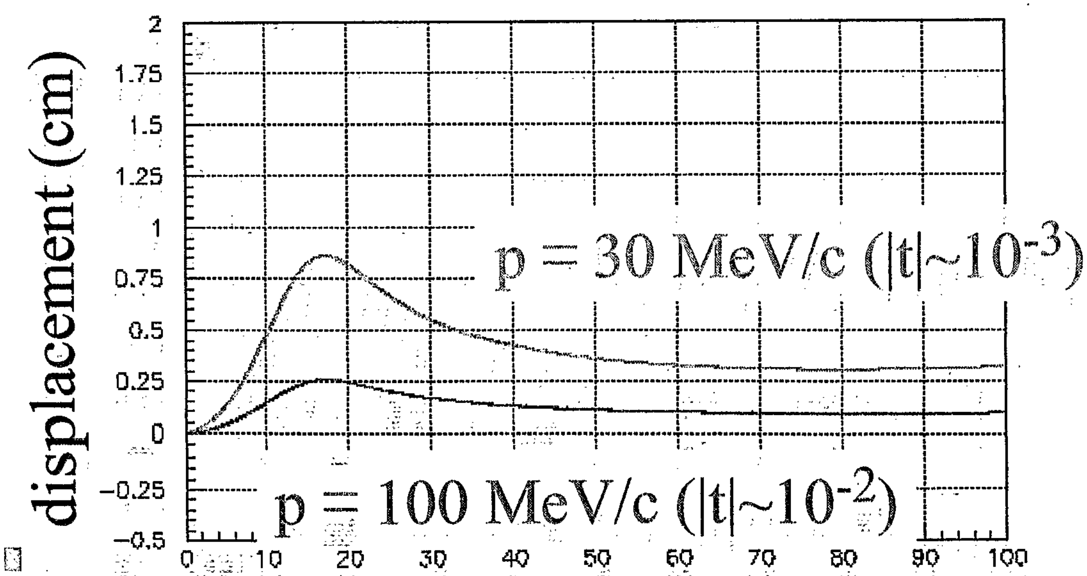
at each step pick-up some measurement errors:

$$\frac{\Delta P_{beam}}{P_{beam}} = \left(\frac{\Delta P_{target}}{P_{target}}\right) \xrightarrow{\oplus} \left(\frac{\Delta\varepsilon}{\varepsilon}\right)_{pp} \xrightarrow{\oplus} \left(\frac{\Delta A_N}{A_N}\right)_{pC} \xrightarrow{\oplus} \left(\frac{\Delta\varepsilon}{\varepsilon}\right)_{pC}$$

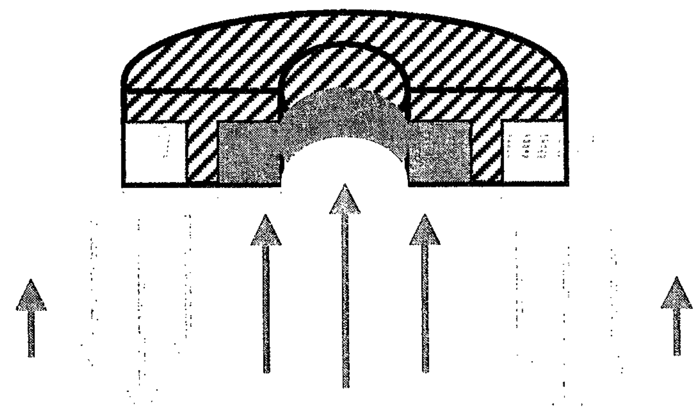
transfer calibration measurement

Jet-Target Holding Magnetic Field (1.0)





Helmholtz coils



almost no effect on recoil proton trajectories:

left – right hit profiles &
left – right acceptances
almost equal
(also under reversal of holding field)

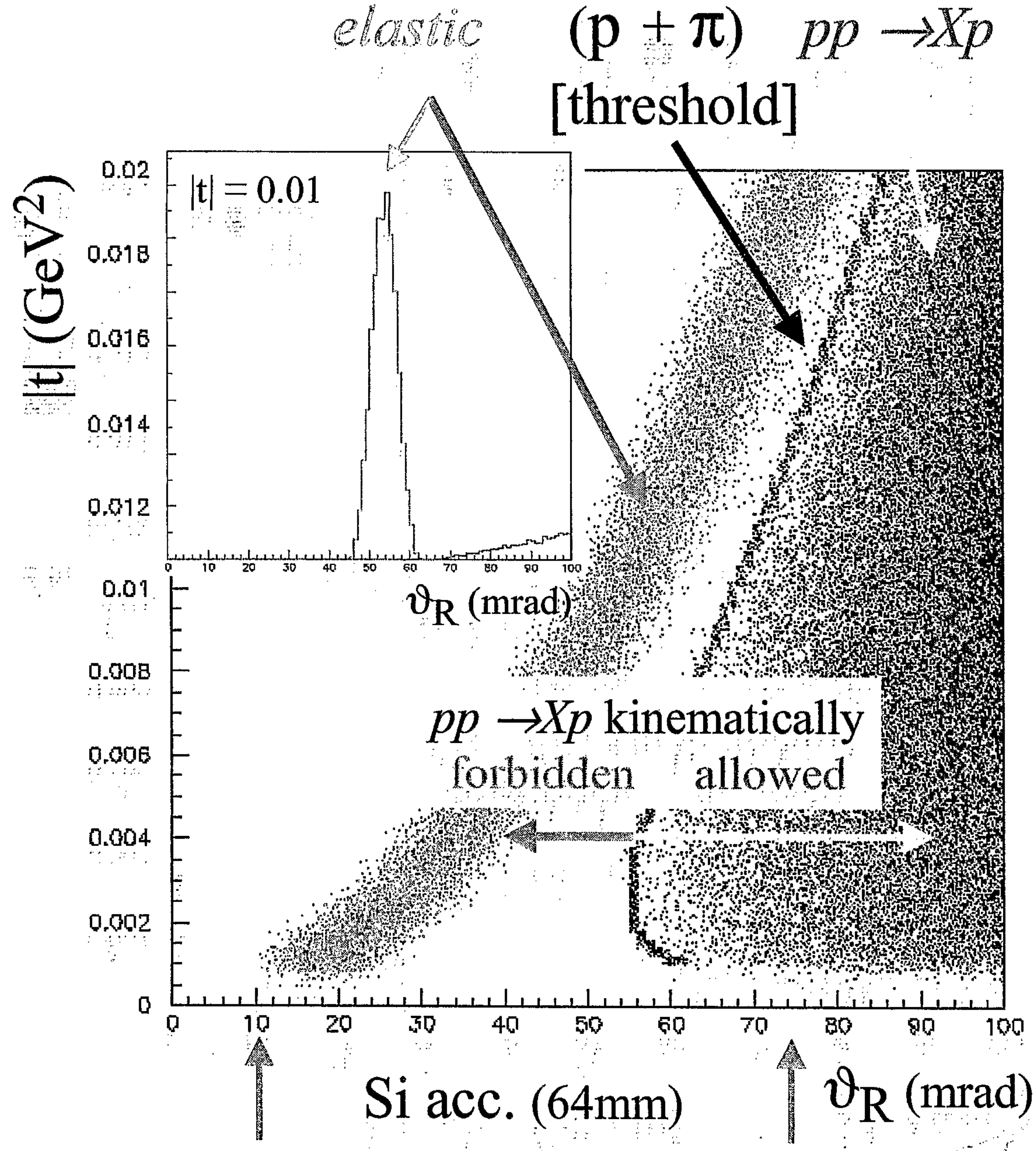
t vs ϑ_R

reconstructed from:
1. deposited energy
2. hit position

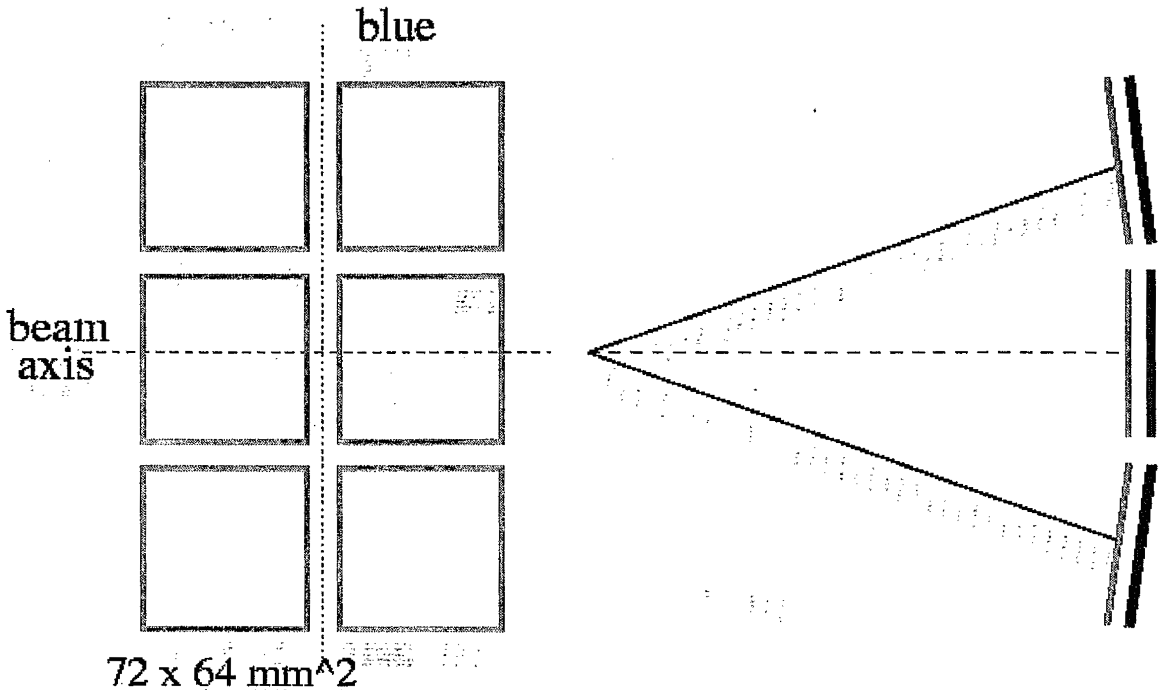
recoil spectrometer resolutions:

$\Delta\vartheta_R$ = targ. ext. / dist.
~ 3 mrad

$|t| = 2\, m_p\, T_{kin}$
$\Delta\, T_{kin} < 100$ keV



Si recoil detector



Requirements

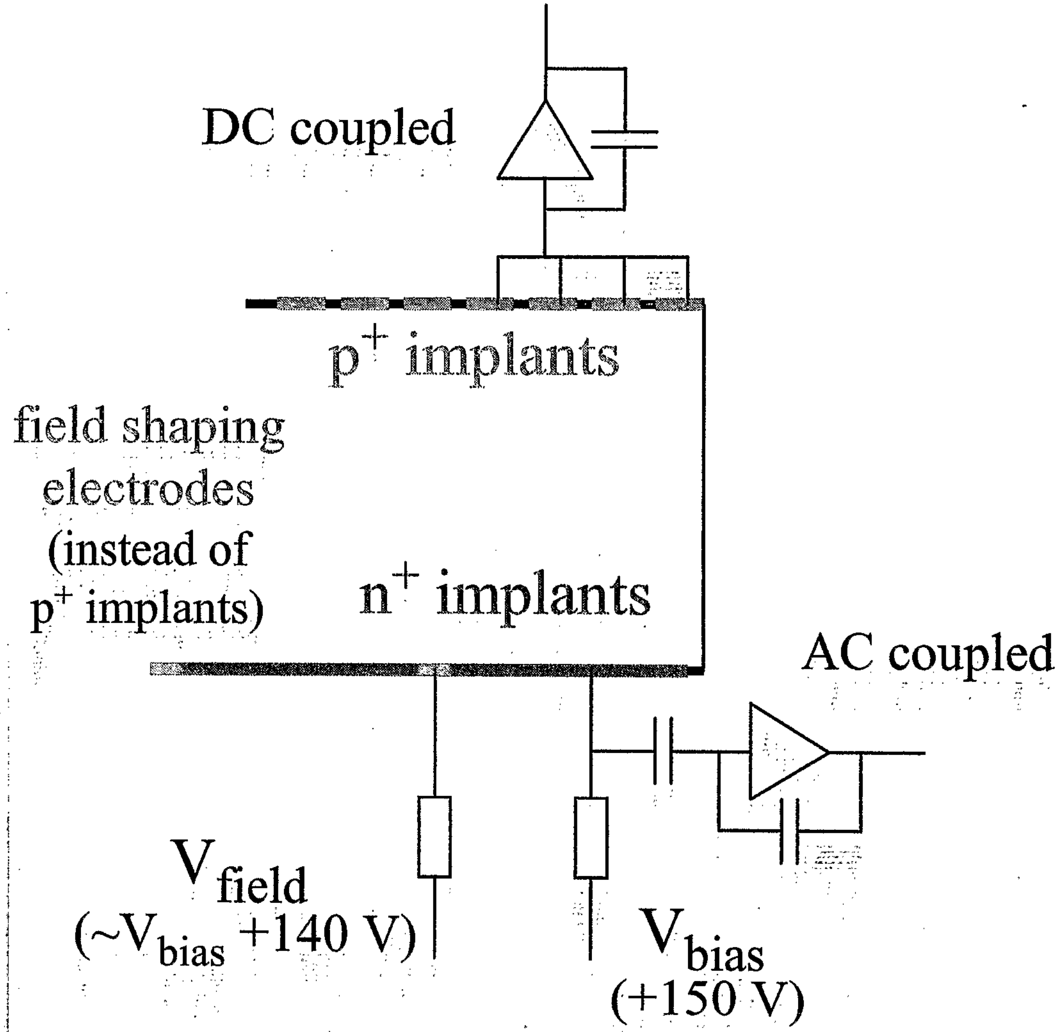
- good energy resolution
  $\Delta E < 0.1$ MeV
- space resolution
  $\Delta x \sim$ few mm
- time resolution
  $\Delta t \sim 2$ ns

horizontal segmentation: 4 mm readout pitch (16 ch.)
vertical segmentation: 8 mm readout (8 ch.) $\Rightarrow \delta\varphi \sim 10$ mrad (optional)

thickness: 0.5 mm $\Rightarrow$ stops up to 8 MeV protons (front detector)
Si stack: 2^{nd} detector 1.0 mm thick
extend t range + veto for punch through protons

<u>MINIMAL SETUP</u>: 2 Si det. for yellow and 2 Si det. for blue beam

Si detector design



double sided readout (opt.)
72×64 mm^2
thickness 500 microns
p^+ side pitch 1 mm
readout pitch 4 mm
n^+ side pitch 4 mm
$C \approx 15$ pF / strip (p^+ side)

Under development (Inst. Div. @ BNL, Zhang Li et al.)

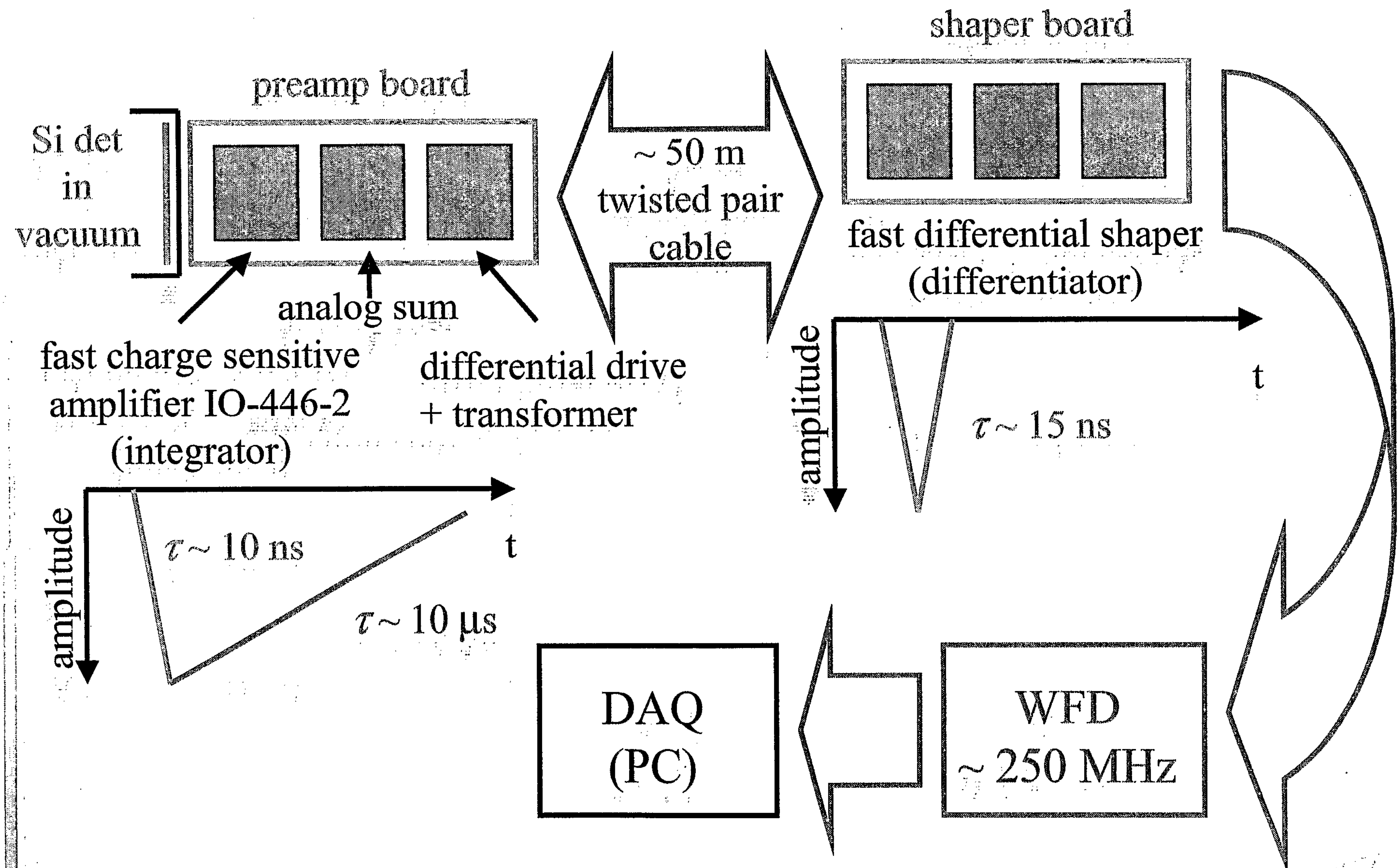
Readout

- 96 channels per beam
  (only front detector and one coordinate)
- Similar to RHIC *pC* polarimeters
  - feed four 1 mm strips to 1 radout channel (4 mm readout pitch)
  - preamplifier boards just outside of vacuum chamber
    hybrid IO-446-2 charge sensitive amplifier
  - signal transport to counting room with coaxial or "differential" cables
  - (differential) fast shapers, $\tau \sim$ 15ns (final τ optimization with S/N)
  - Wave Form Digitizers (Yale)
- Low Rate
  - can record waveform for each event
- Under development (with BNL Inst. and Yale: S. Dawhan)

DAQ, on- & off-line

- record waveforms
  - triggering algorithm
  - event building
  - integration with JET slow control
- online analysis of waveforms
  - analysis of AGS/RHIC data
  - multihit TDC & ADC algorithms
- offline analysis
  - asymmetry extraction -> P_B, A_{0N}, A_{N0}, A_{NN}
  - systematic studies
  - Monte Carlo (French Riviera !) -> Las Vegas (US desert)

Readout schematics



Timelines for FY04 running

- Si detectors:
  - 1st processing of Si wafers completed
  - testing with FE electronics these days
  - if OK proceed with mass production -> 07/15

  minimal setup for FY04: 4 (2) detectors

- Readout:
  - "conceptual" design completed
  - layout of FE and shaper boards under way
  - development of new WFD in progress @ Yale

Thoughts on Polarized p+p in Run-4 and Beyond from STAR

L. Bland, BNL

June 20, 2003

for

RHIC Spin Collaboration Meeting XVII

RIKEN BNL Research Center

Polarized Protons for Run 4

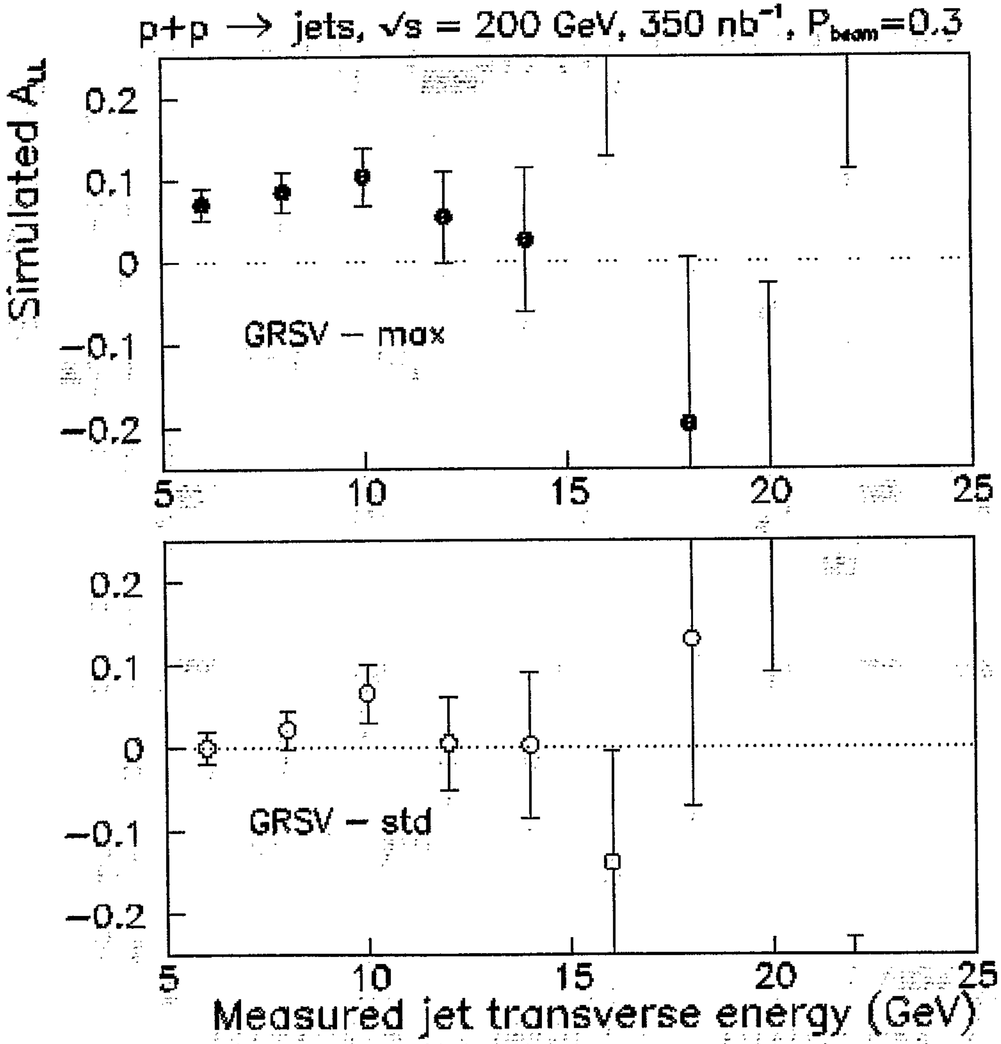
Caveats and Comments:

- Formal discussions within the STAR collaboration about Run 4 are just beginning.
- Initial discussions about Run 4 by the STAR spin physics working group were held yesterday.
- Guidance from August, 2002 STAR Multi-Year Beam Use Request regarding run 4:

Au+Au	$\sqrt{s_{NN}}$=200 GeV	16 weeks
Au+Au	$\sqrt{s_{NN}}$=20 GeV	1 week
Au+Au	$\sqrt{s_{NN}}$=40 GeV	1 week
Au+Au	$\sqrt{s_{NN}}$=80 GeV	1 week
pol. p+p	$\sqrt{s}$=200 GeV	~8 weeks

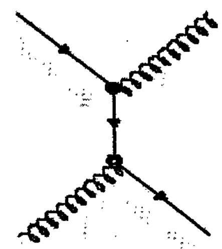
$\Rightarrow$ continuation of A_{LL} measurement

Projections for Sensitivity to ΔG from Run 3



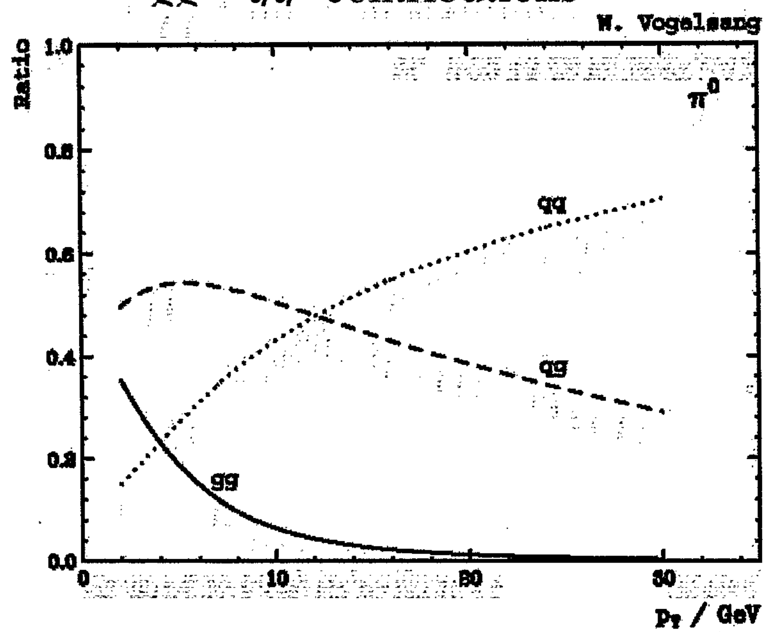
Longitudinal spin asymmetry (A_{LL}) for mid-rapidity jet production

$\Rightarrow$ first measurements sensitive to gluon polarization



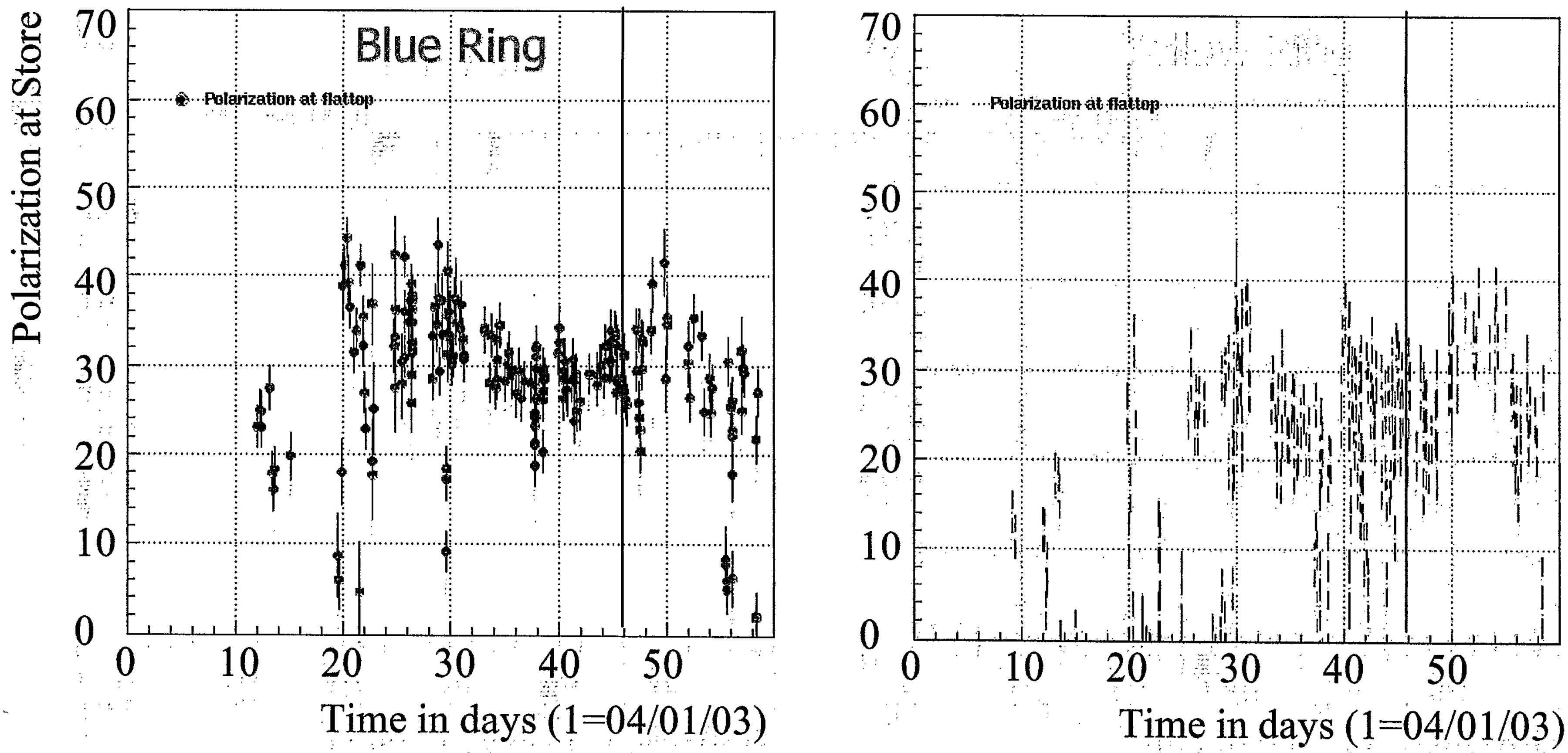
$qg \rightarrow qg$

$+ gg + qq'$ contributions



RHIC Polarization at store for Run 3

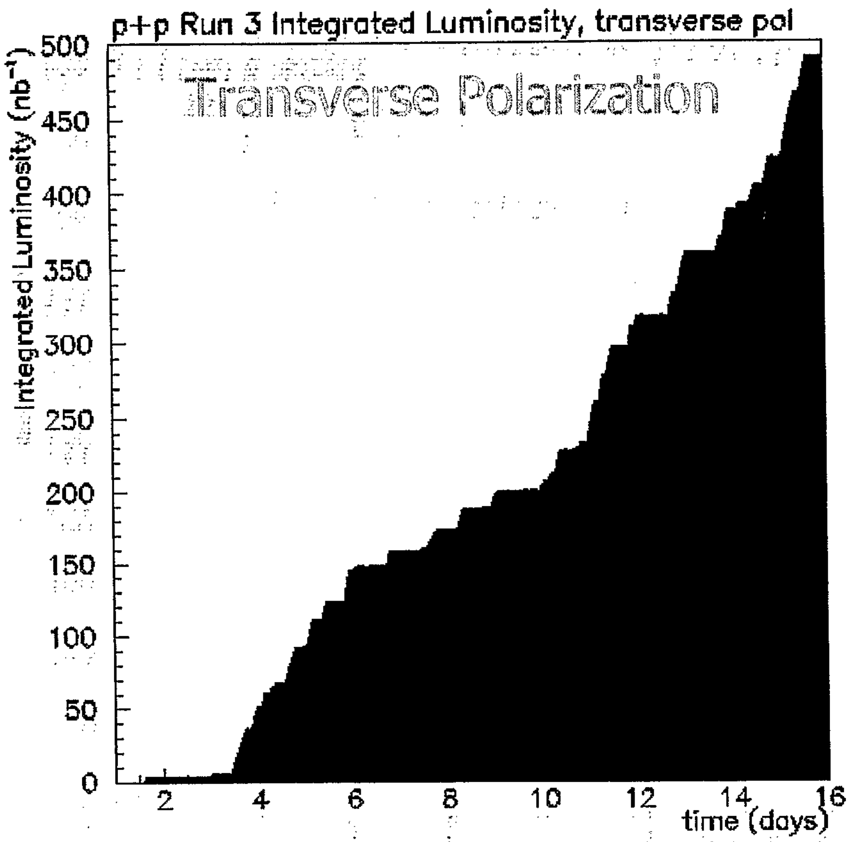
⇒ Longitudinal polarization at STAR after May 15

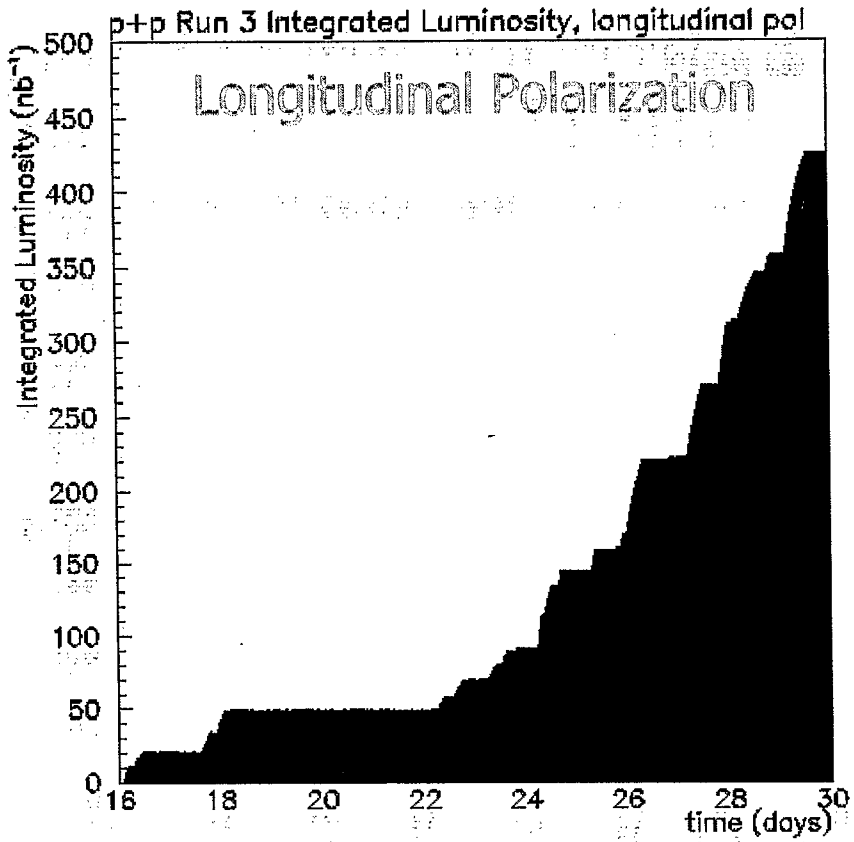


- RHIC polarization improved by factor of ~2 compared to run 2
- Yellow ring affected by problem with snake magnet

STAR spin

p+p Integrated Luminosity for Run 3 Delivered to STAR IR





- $\int \mathcal{L}\, dt$ determined from STAR beam-beam counter in May, 2003.
- Approximately half of the delivered $\int \mathcal{L}\, dt$ for longitudinal polarization had all STAR subsystems at operating voltages.

Summary of Run 3 Sensitivity to ΔG

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Plans versus Reality

- Polarization: plan was $P^2=0.09$ / reality was $P^2\sim0.06$
- $\int \mathcal{L}\,dt$: plan was 350 nb^{-1} / reality was ~200 nb^{-1} recorded

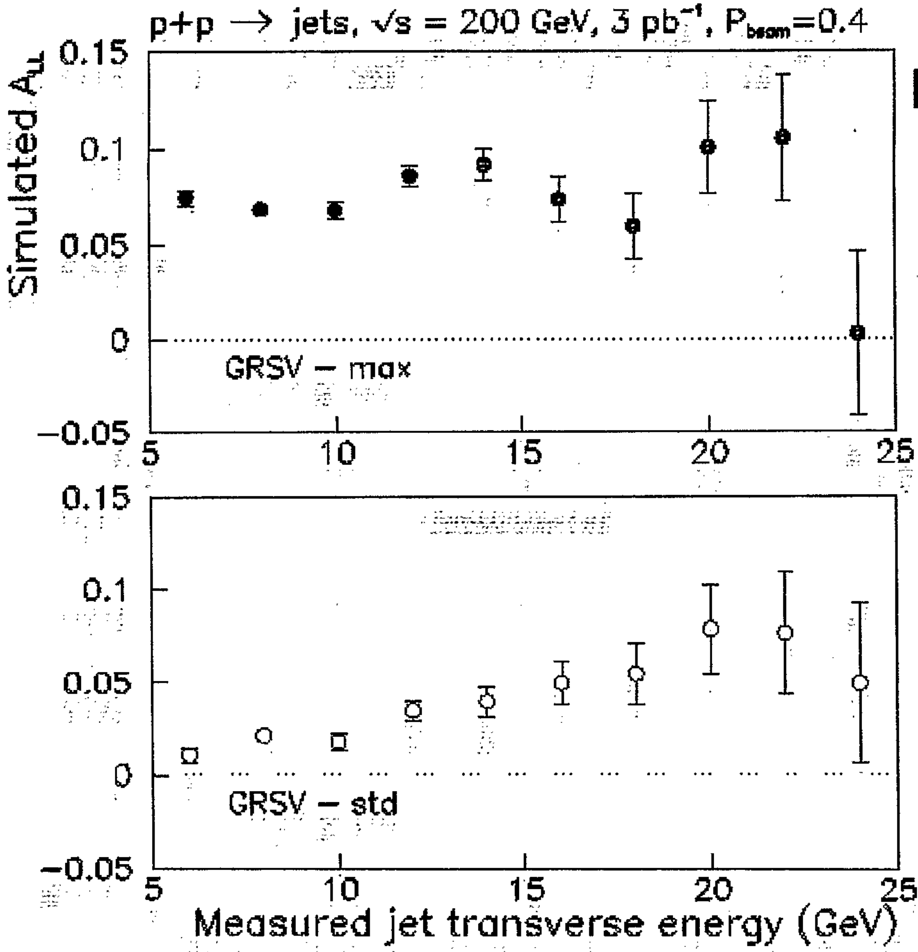
Analysis Tasks towards ΔG sensitivity

- incorporate barrel EMC data into jet finder
- understand trigger bias on inclusive jet production
- analyze relative luminosity data

STAR spin

STAR spin

Some Thoughts on Run 4



Likely goals for polarized protons in run 4

- Commissioning of RHIC/AGS complex (~5 weeks)
  - o Progress towards goal of ~30 pb^{-1}/week, with P_{beam}=70%
  - o Commissioning of polarized gas jet target: FY04 goal $\Delta P/P \sim 10\%$ at 100 GeV
- Physics Running (~3 weeks)
  - o contingent on $P^4 \times \mathcal{L}_{avg\ week} > 10\ nb^{-1}$ ($\mathcal{L}_{avg\ week} > 1\ pb^{-1}$ P>30%)

- Simulation based on Pythia including trigger and and jet reconstruction efficiencies
- Assume: Coverage of EMC (barrel) $0 < \phi < 2\pi$ and $0 < \eta < 1$
- Jet Trigger: E_T > 5 GeV over at least one "patch" $(\Delta\eta = 1) \times (\Delta\phi = 1)$
- Jet reconstruction: Cone algorithm (seed = 1 GeV, R = 0.7)

Expect 75% of barrel and completed endcap EMC for Run 4

Longer Range Issues

- Credible plan for increase in polarized proton luminosity

- Progress towards higher luminosity & polarization in each run

- Focus on long polarized proton run at $\sqrt{s}$ = 500 GeV is contingent on projected $\int \mathcal{L}\, dt$ and beam polarization.

Thought from PHENIX on Aims for Run-4 Polarized Proton Run

RSC Meeting

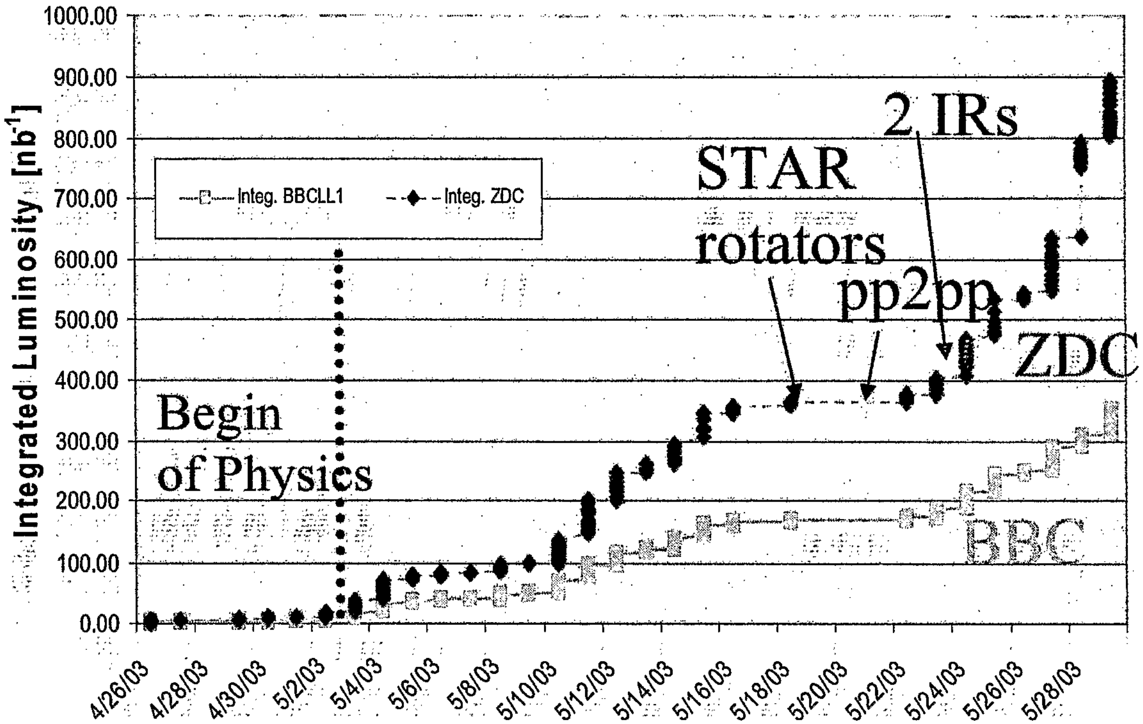
June 20, 2003

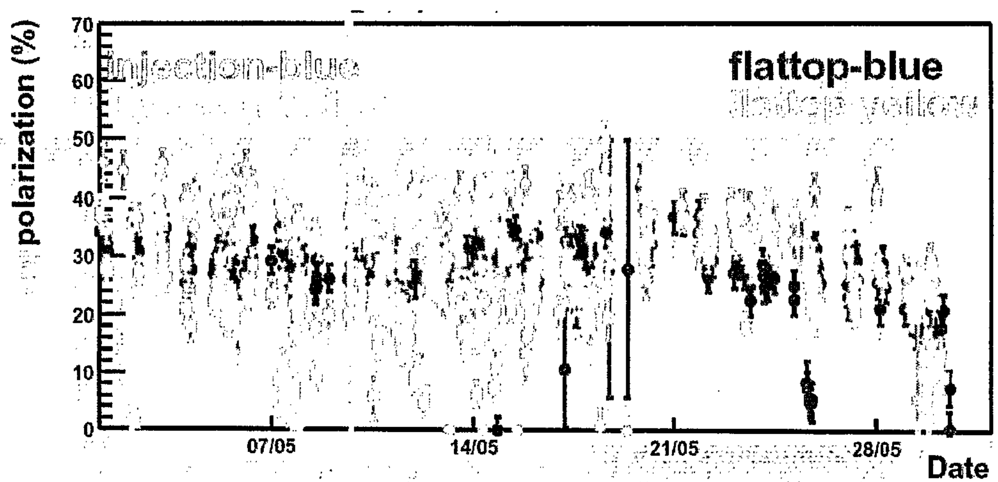
Yuji Goto (RIKEN/RBRC)

Run-3

- integrated luminosity 350nb^{-1} from 6.6×10^{9} BBCLL1 triggers
- average polarization 27%
- figure of merit

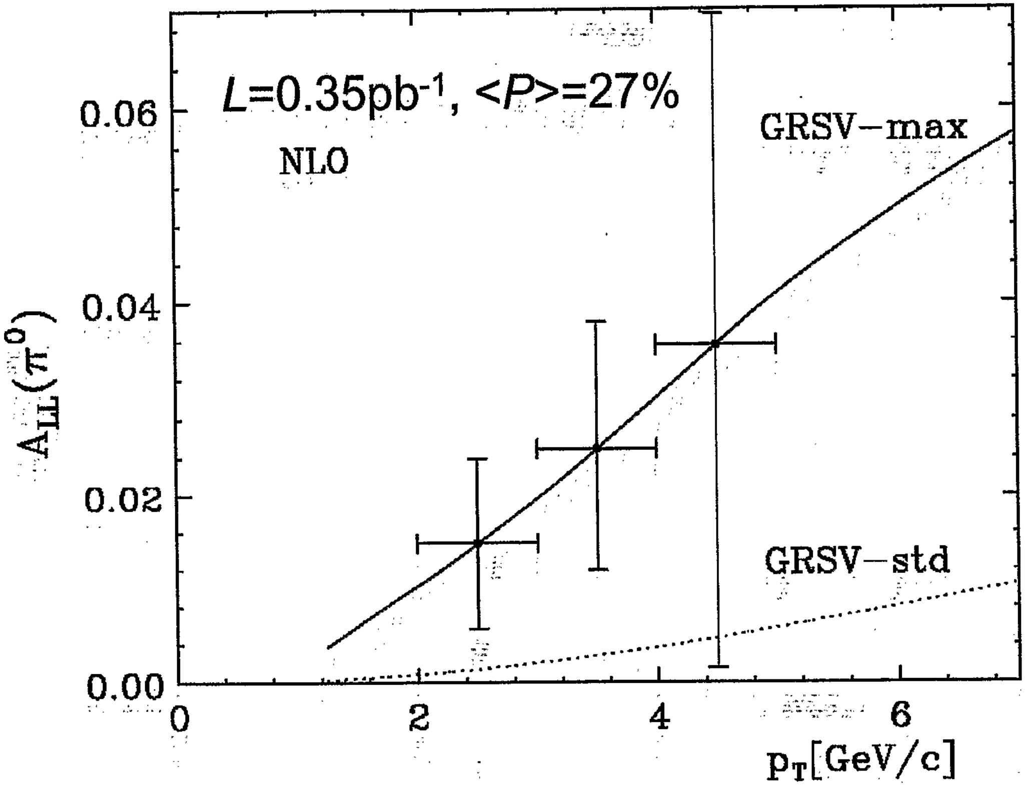
$$\int P_Y^2 P_B^2 L dt = 1.8\ \mathrm{nb}^{-1}$$



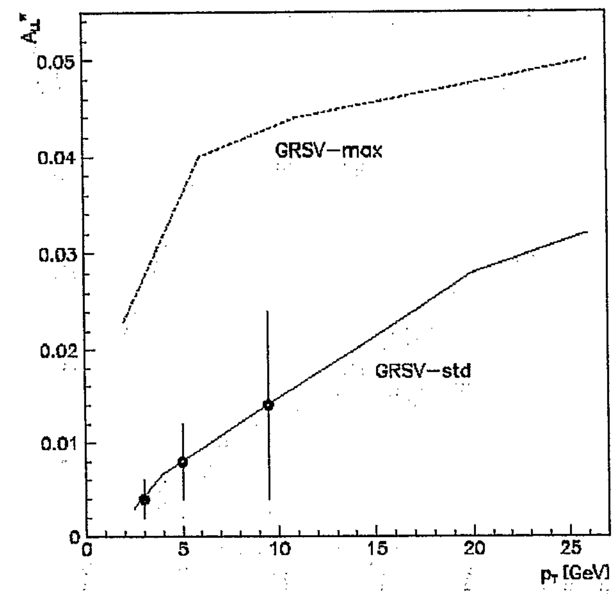


Run-3

- π^0 A_{LL} expectation



Run-3 beam-use proposal
(August 2002)
L=3pb^{-1}, $<P>$=40%



- our π^0 cross section analysis showed that even at p_T~2GeV/c, the hard scattering gives dominant contribution
- but, how about the asymmetry measurement ?

Run-3 (and Run-2)

- other analysis ongoing
  - π^0 A_N
  - J/ψ polarization
  - charged hadron
  - single muon/electron
  - BBC/localpol asymmetries
  - …

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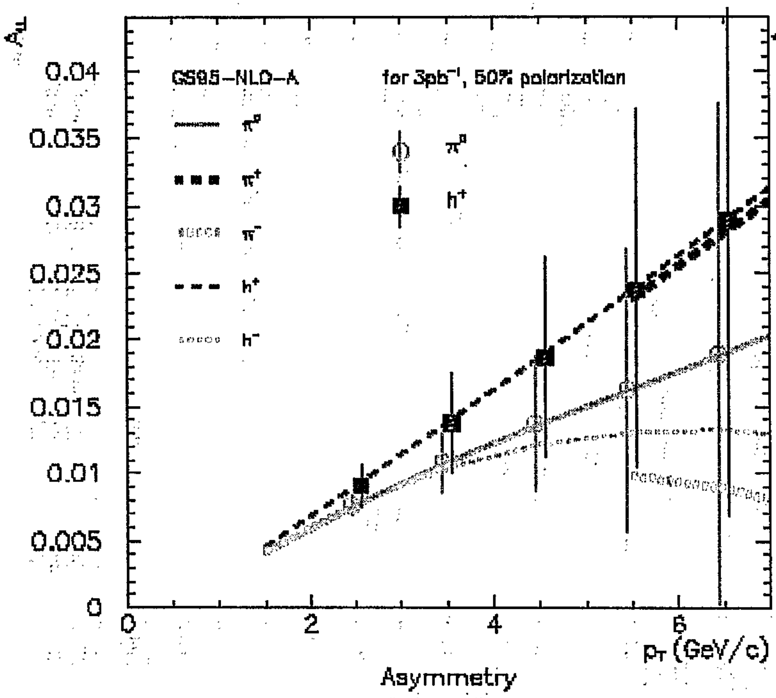
Plan in July, 2002

	Pol.	root(s)	weeks (commission / physics)	Luminosity / week	Integrated luminosity	
Run-3 (2003)	50%	200GeV	8 (5 / 3)	3/pb	9/pb	
Run-4 (2004)	50%	200GeV	5 (1 / 4)	20/pb	80/pb	gluon polarization with pi0 / hadron
		500GeV	3 (2 / 1)	20/pb	20/pb	
Run-5 (2005)	70%	200GeV	7 (1 / 6)	20/pb	120/pb	gluon polarization with direct photon
		500GeV	3 (1 / 2)	50/pb	100/pb	
Run-6 (2006)	70%	200GeV	6 (1 / 5)	20/pb	100/pb	
		500GeV	4 (1 / 3)	50/pb	150/pb	anti-quark polarization with W
Run-7 (2007)	70%	500GeV	10 (1 / 9)	50/pb	450/pb	

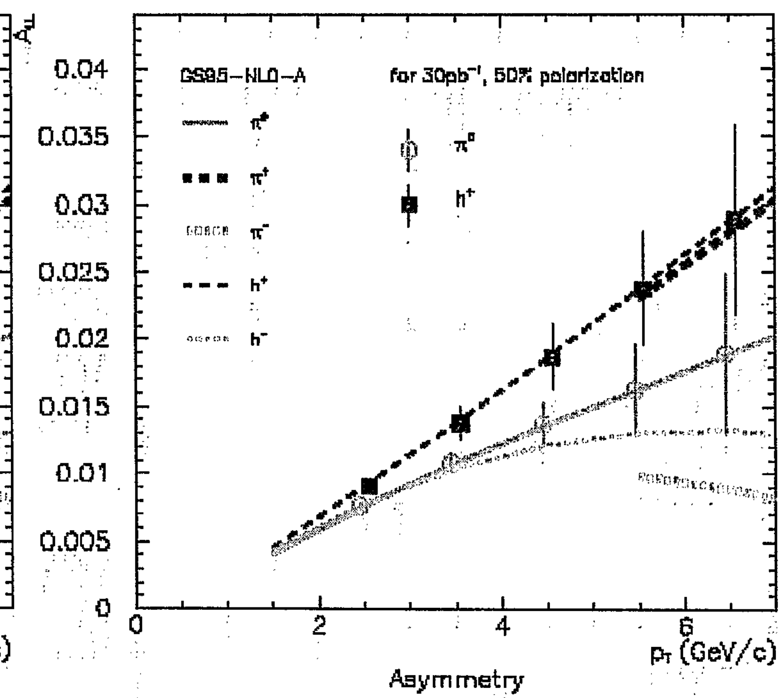
– physics menu development with lower luminosity / polarization would be important …

Run-4 ?

- menu with 1% luminosity (3pb^{-1})
  - π/hadron



L=3pb^{-1}, <P>=50%



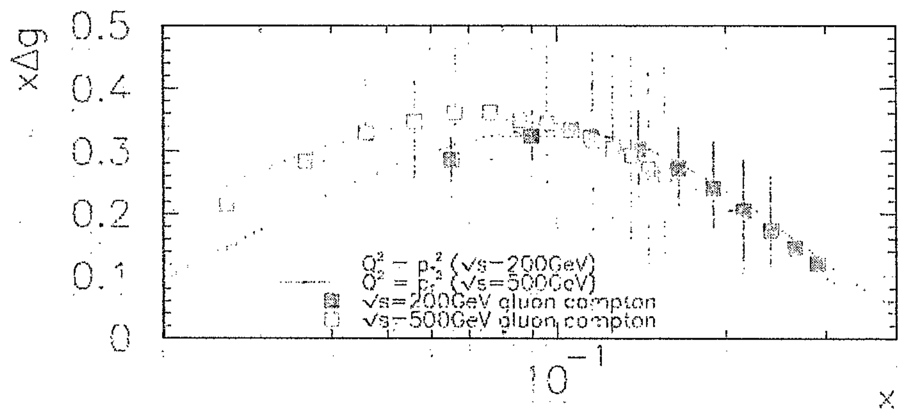
L=30pb^{-1}, <P>=50%

Run-4 ?

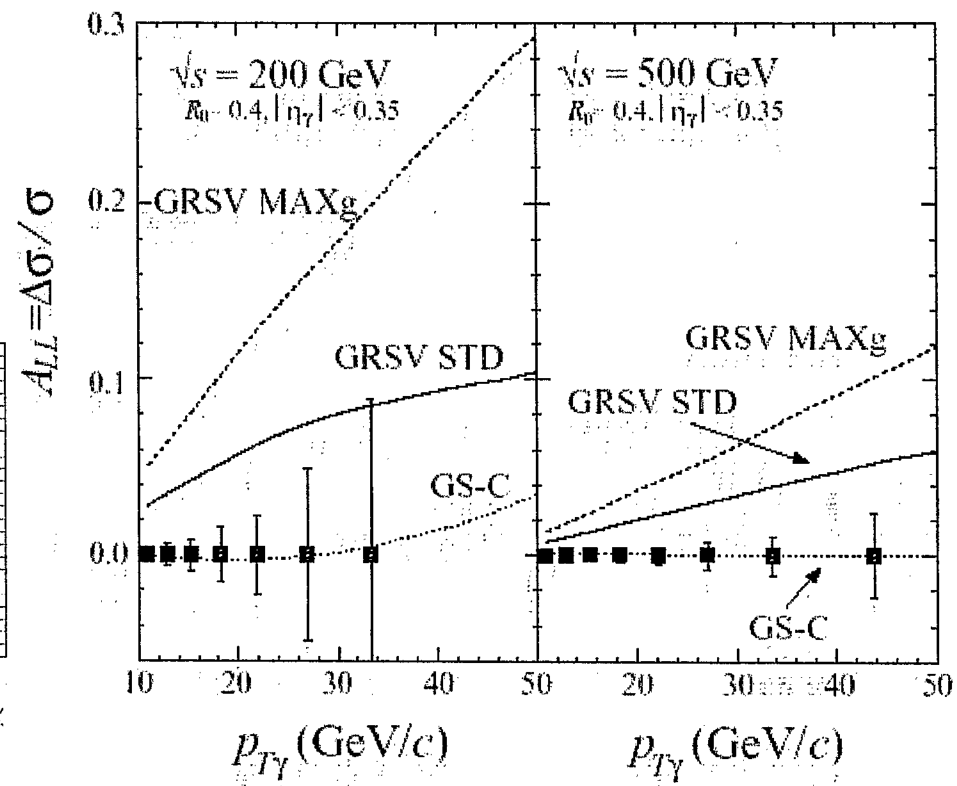
- menu with 1% luminosity ($3pb^{-1}$)
  - single electron
    - ~1M for p_T>1GeV/c with bg/signal=1~4
  - J/ψ
    - ~10K
    - χ_c ~20?, ψ(2S)~100?, …
  - open heavy flavor (charm)
    - $\mu\mu$ ~4000, eμ ~7000
  - direct photon
    - ~20K for p_T>5GeV/c with bg/signal~1 (after isolation cut)

And beyond …

- 500GeV
  - weak boson
    - W trigger ?
    - background ?
  - direct photon
    - statistical significance ?
    - x_{gluon} coverage ?

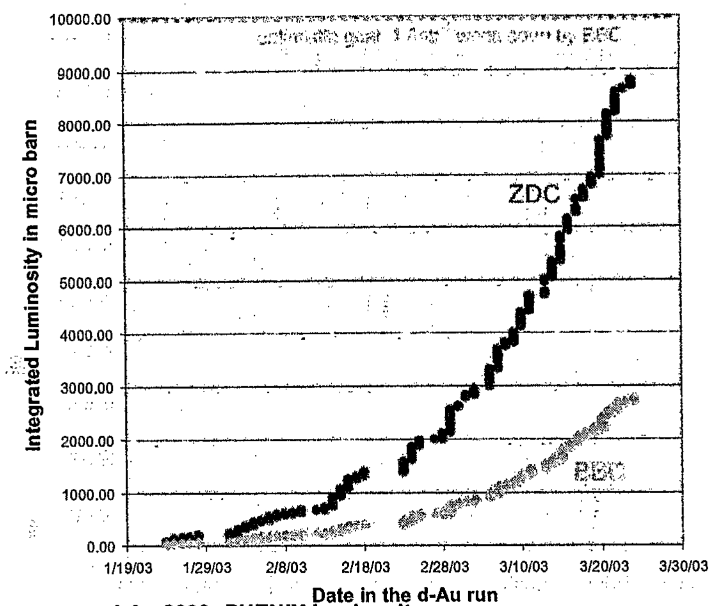


inclusive photon

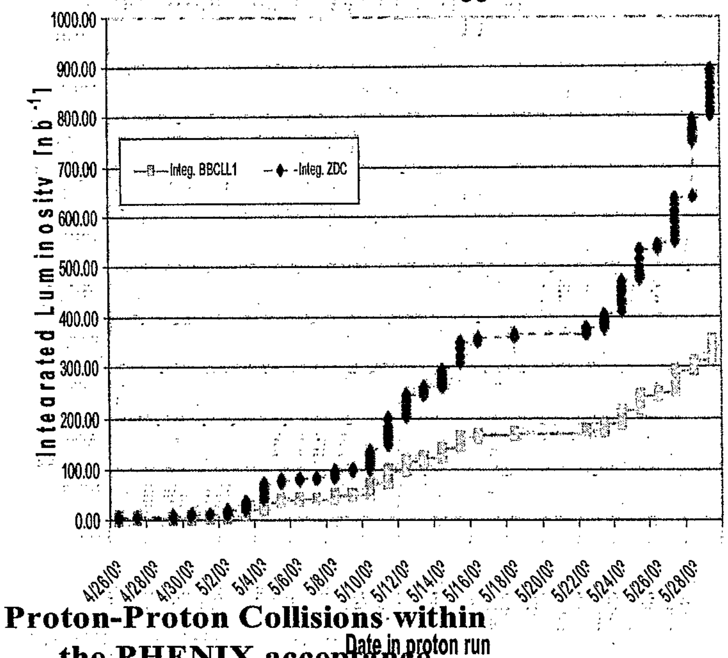


Run-3 vertex ...

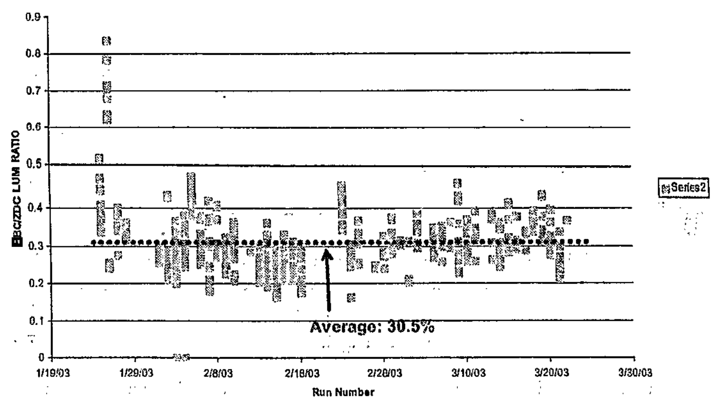
d-Au Run 2003 Integrated Luminosity: 2.7 nb^{-1}
corresponding to 5.5x109 BBC.LL1 events sampled



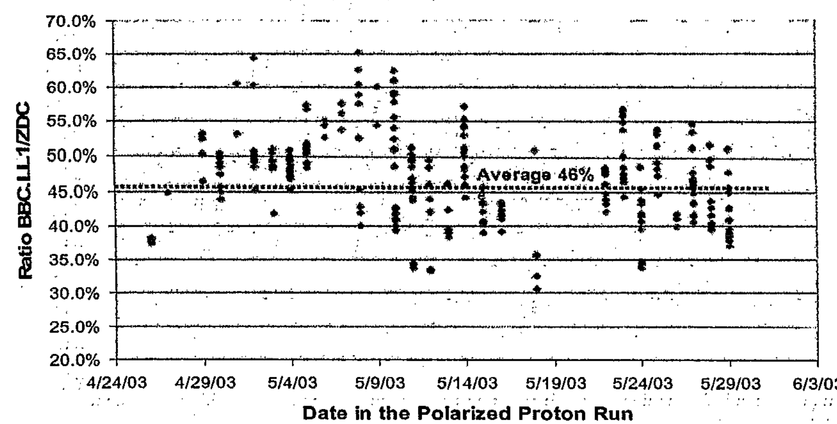
pp-run-03 PHENIX integrated luminosity
352 nb^{-1} from 6.6x10^9 BBCLL1 triggers



d-Au 2003: PHENIX luminosity
delivered within acceptance



Proton-Proton Collisions within
the PHENIX acceptance



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Thoughts on Polarized p+p in Run-4 and Beyond from BRAHMS

B. Fox, RBRC

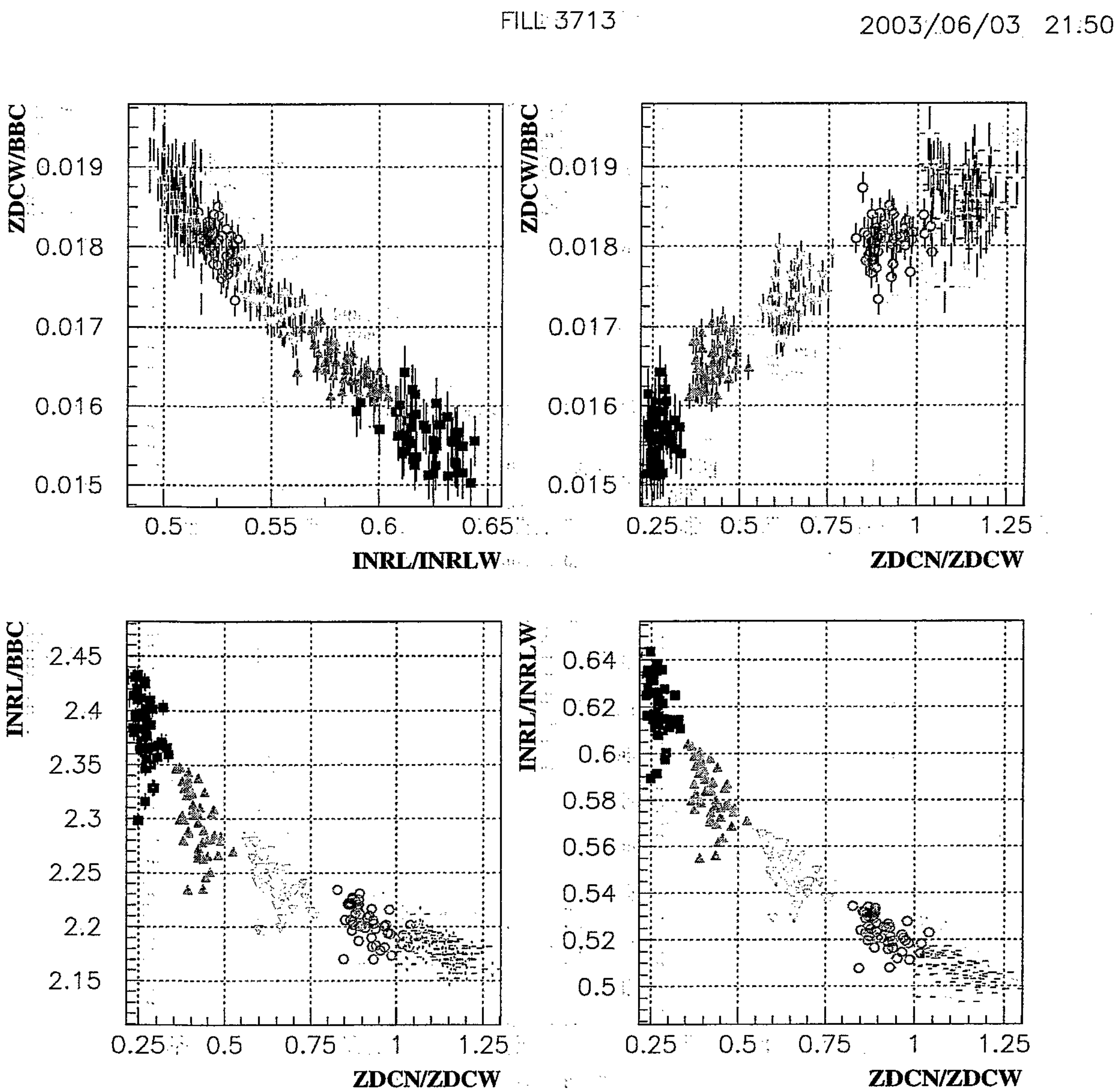
June 20, 2003

for

RHIC Spin Collaboration Meeting XVII

RIKEN BNL Research Center

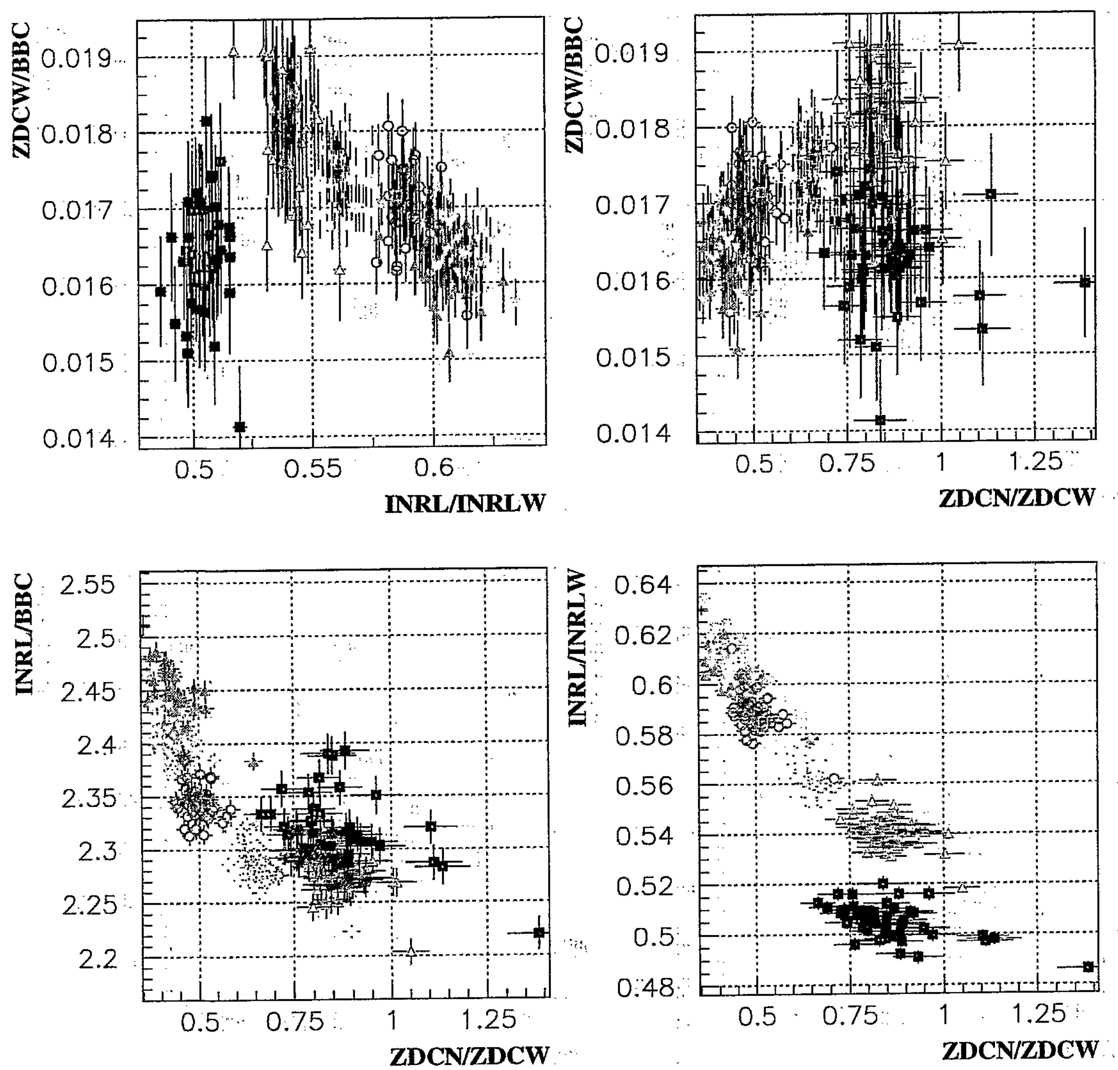
Golden Fill (May 14 Owl) - #3713



- ZDCN=RC .AND. ZDC_YELLOW (due to mistake)
- Time in Fill is shown with COLOR ...
  BLACK, RED, GREEN, BLUE,
- 1st run in fill - no background issues (not typical)
- Panel Left/Top - clear trend with vertex width?

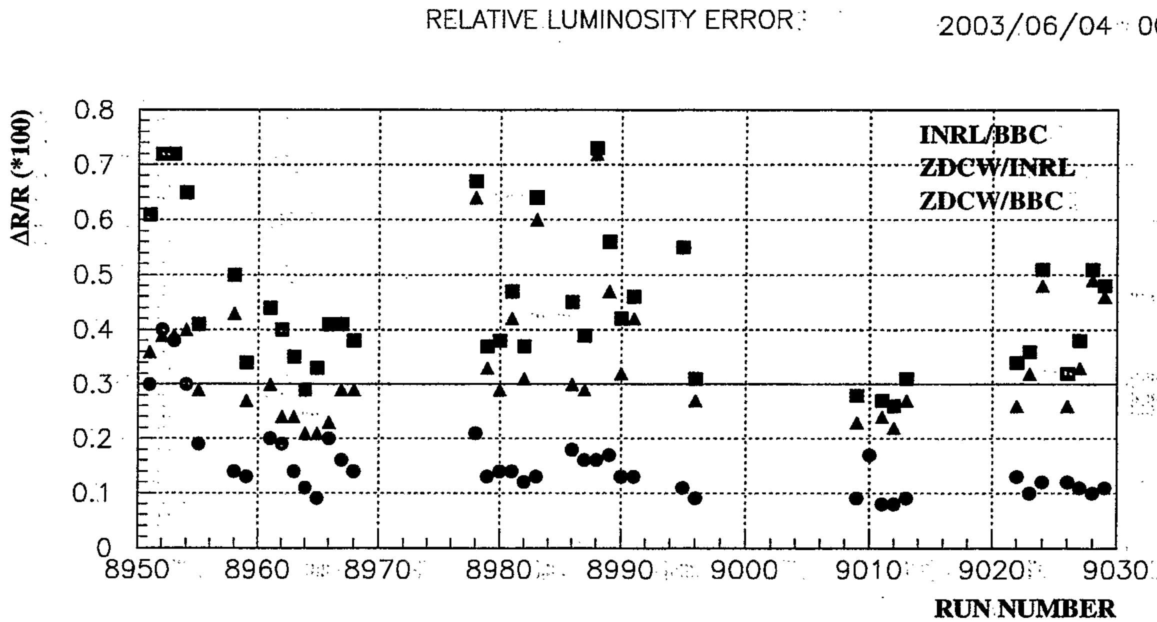
Sample Fill (May 17th Day) - #3732

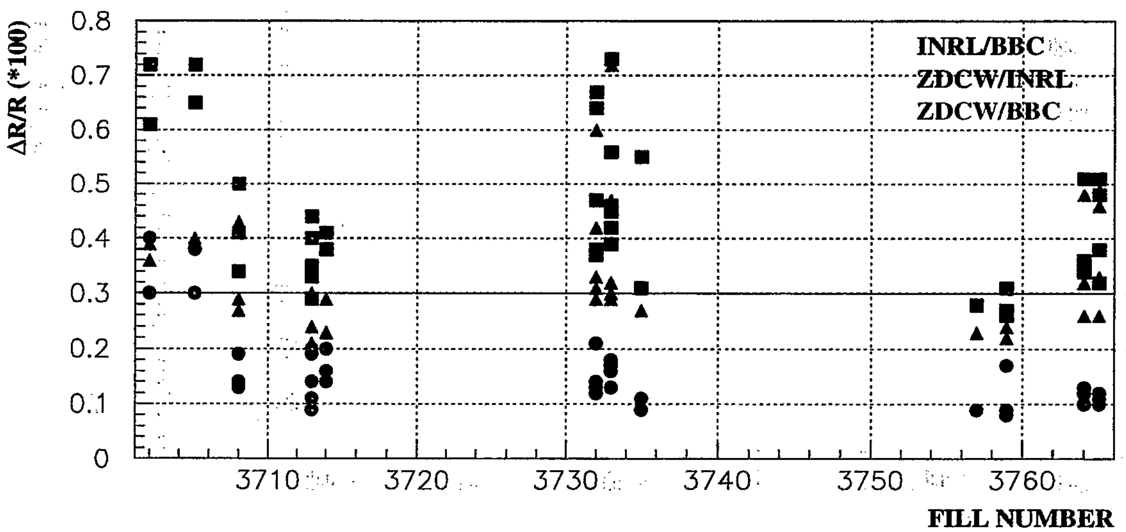
FILL 3732 2003/06/03 21.50



- ZDCN=RC .AND. ZDC_YELLOW (due to mistake)
- Time in Fill is shown with COLOR ...
  BLACK, RED, GREEN, BLUE, MAGENTA
- 1st run in fill - background issues (not atypical)
- Panel Left/Top - trend with vertex width?

Relative Luminosity Error -vs- Time





- For $A_N \sim 1\%$, need $\Delta R/R < 0.3\times10^{-2}$ since $\vec{p}_b \sim 30\%$.
- See changes w/in fill, *e.g.*, INRL/BBC at Run ~8960.
- Measurement w/ZDC limited by statistics.
- BBC & INRL look good, $\Delta R/R < 0.3\%$.
- Bunch-by-bunch correction for vertex widths ... improve? ... match FS acceptance? ... to do!

Subject: BRAHMS A_N measurement

If we chose to measure pi+ instead of pi-, then the analyzing power would be a factor of 2-3 larger (probably even more) ... just to remind you, the E704 data are:

x_f	A_N(pi+)	A_N(pi-)
0.27	0.06+/-0.04	0.02+/-0.04
0.36	0.12+/-0.02	-0.04+/-0.02
0.45	0.21+/-0.02	-0.11+/-0.01

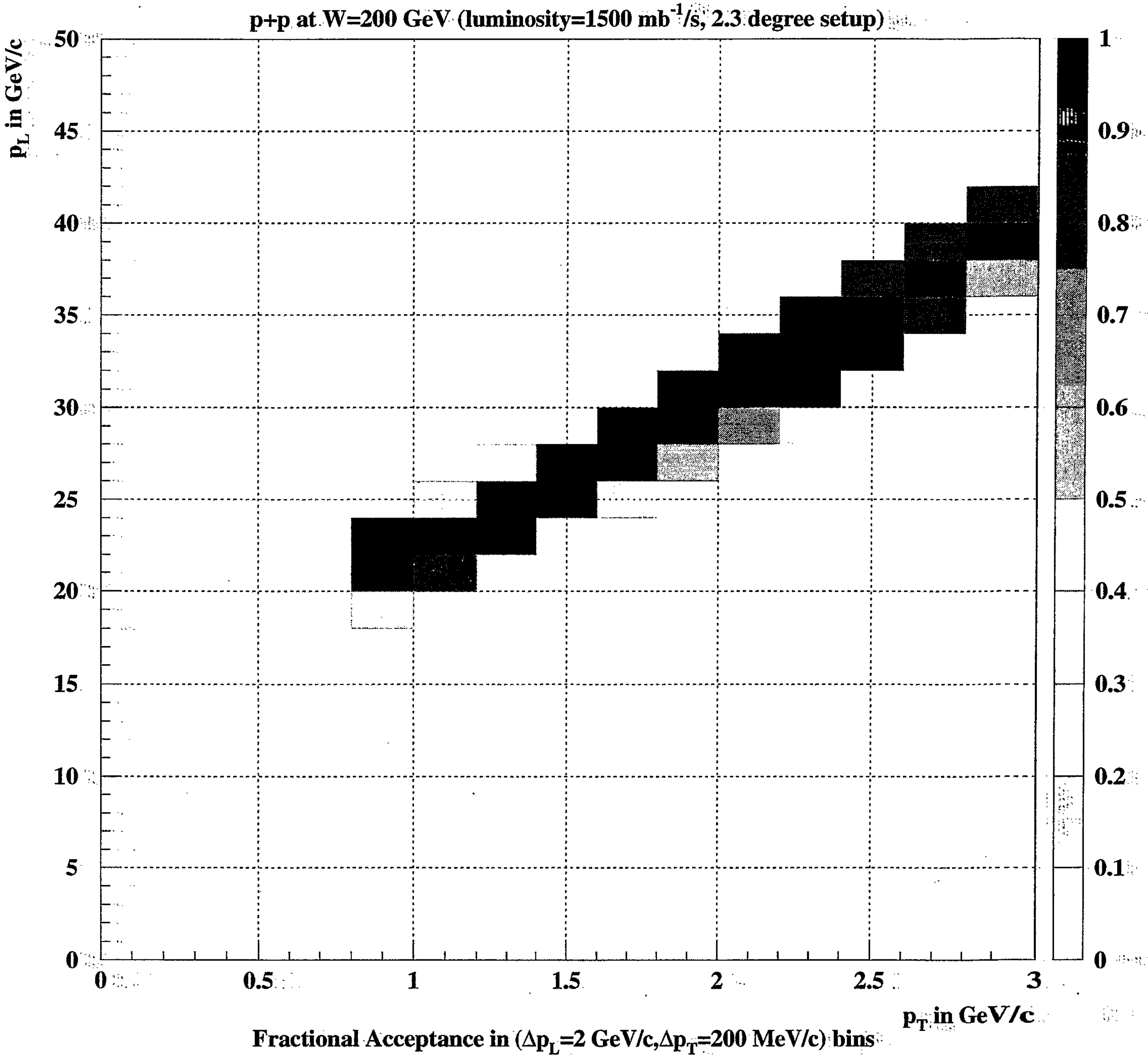
Also, the production rate goes up a bit, I think. If the analyzing power (A_N) is 3-6%, then the raw asymmetry would be 1-2%. A 3-sigma (relative to zero) measurement would thus require only 110K-55K events.

Based on Run-3 data, staying at 3.5 degrees, we have:

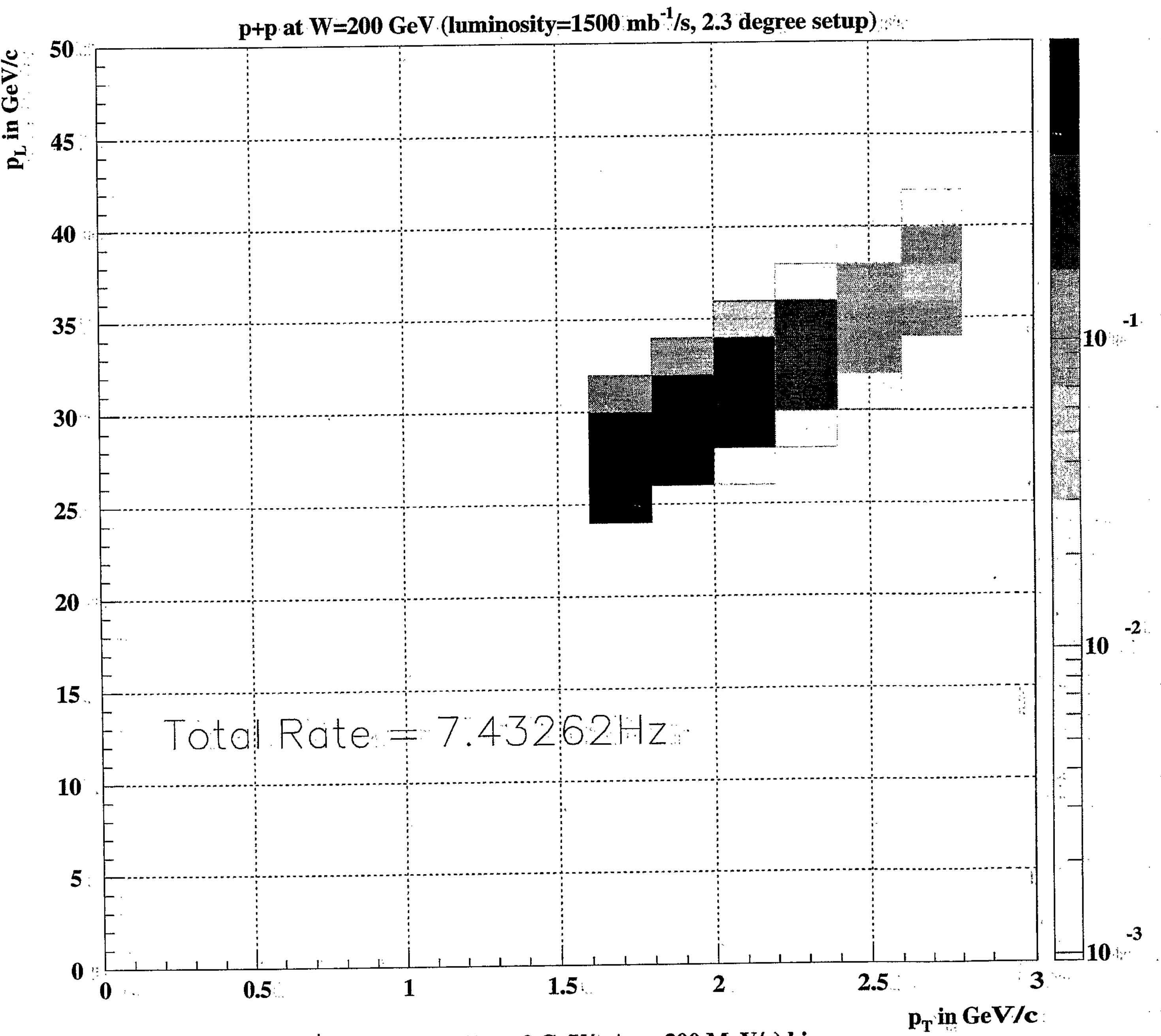
x_f	rate	raw asym of 1%	raw asym of 2%
0.20	16K/hour	110K (7 hours)	55K (3.5 hours)
0.25	4K/hour	110K (28 hours)	55K (14 hours)

The pi+ rate, being higher, probably means that we would be able to do the xf=0.25 measurement in a day, event if the raw asym is of the order of 1%.

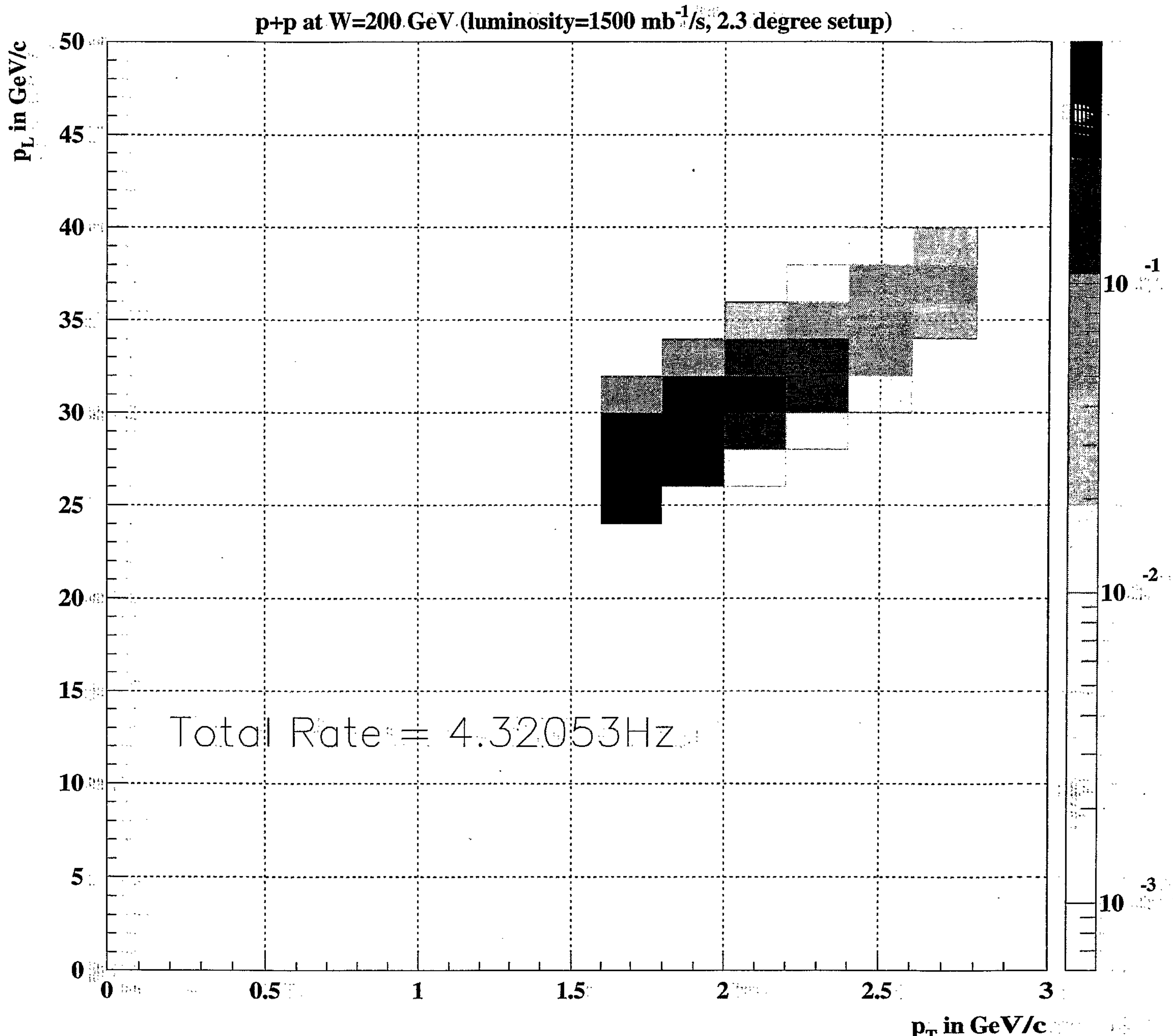
Moving to 2.3 degrees will make this easier plus we extend to higher xf, hopefully 0.4. The rate estimate needs to be firmed at this angle.



Fractional Acceptance in (Δp_L=2 GeV/c,Δp_T=200 MeV/c) bins



π^+ rate in Hz in (Δp_L=2 GeV/c,Δp_T=200 MeV/c) bins



π^- rate in Hz in (Δp_L=2 GeV/c,Δp_T=200 MeV/c) bins

Plans for the Future of pp2pp

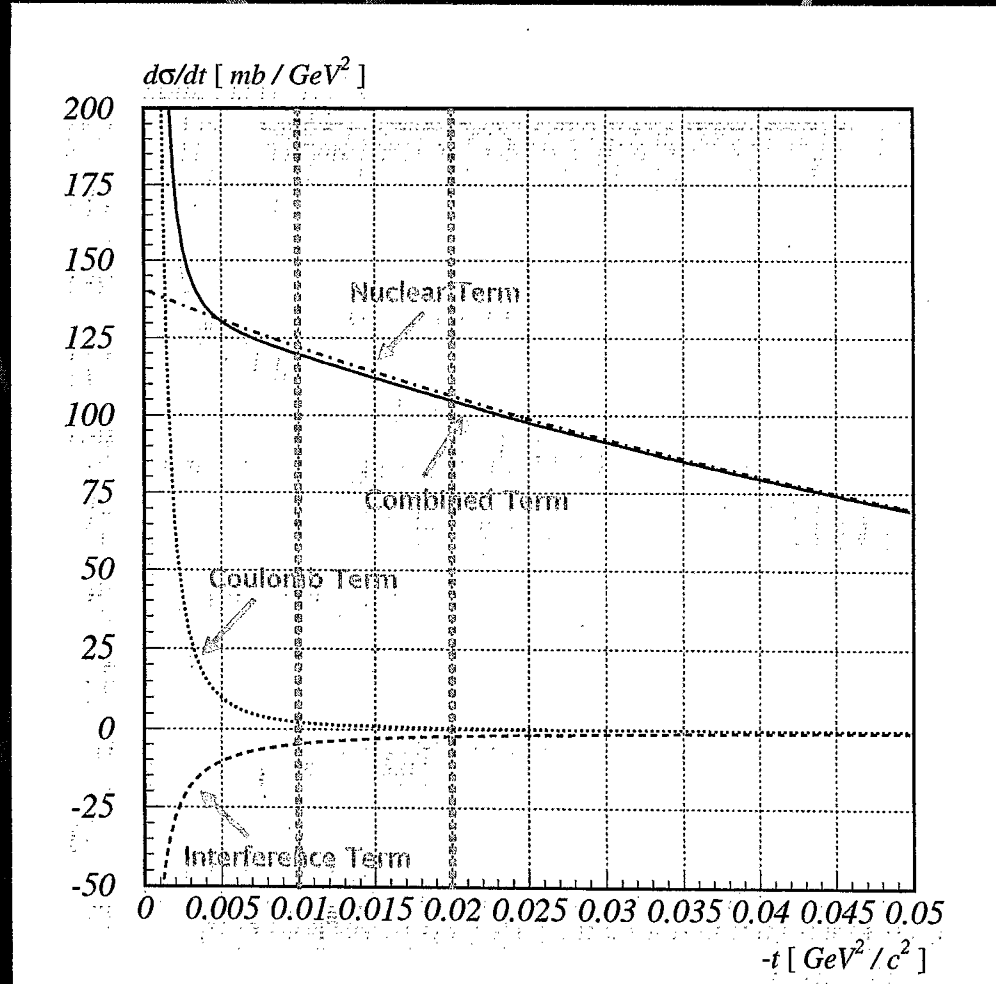
Stephen Bültmann
Brookhaven National Laboratory

- Introduction
- Scenarios

RHIC Spin Collaboration Meeting, June 20, 2003

Differential Elastic Cross Section

$$\frac{d\sigma}{dt} = \frac{4\pi\,(\alpha\,G_E^{\,2})^2}{t^2} + \frac{(1+\rho^2)\,\sigma_{tot}^{\,2}\,e^{+Bt}}{16\,\pi} + \frac{(\rho+\Delta\Phi)\,\alpha\,G_E^{\,2}\,\sigma_{tot}\,e^{+\frac{1}{2}Bt}}{t}$$



$\Delta\Phi$ = Coulomb Phase

G_E = Proton Electric Form Factor

Input : $\sigma_{tot} = 52$ mb

$\rho = 0.13$

$B = 14\ \mathrm{GeV}^{-2}$

Overview of Elastic Scattering Data

pp2pp Energy Range

50 GeV $\leq \sqrt{s} \leq$ 500 GeV

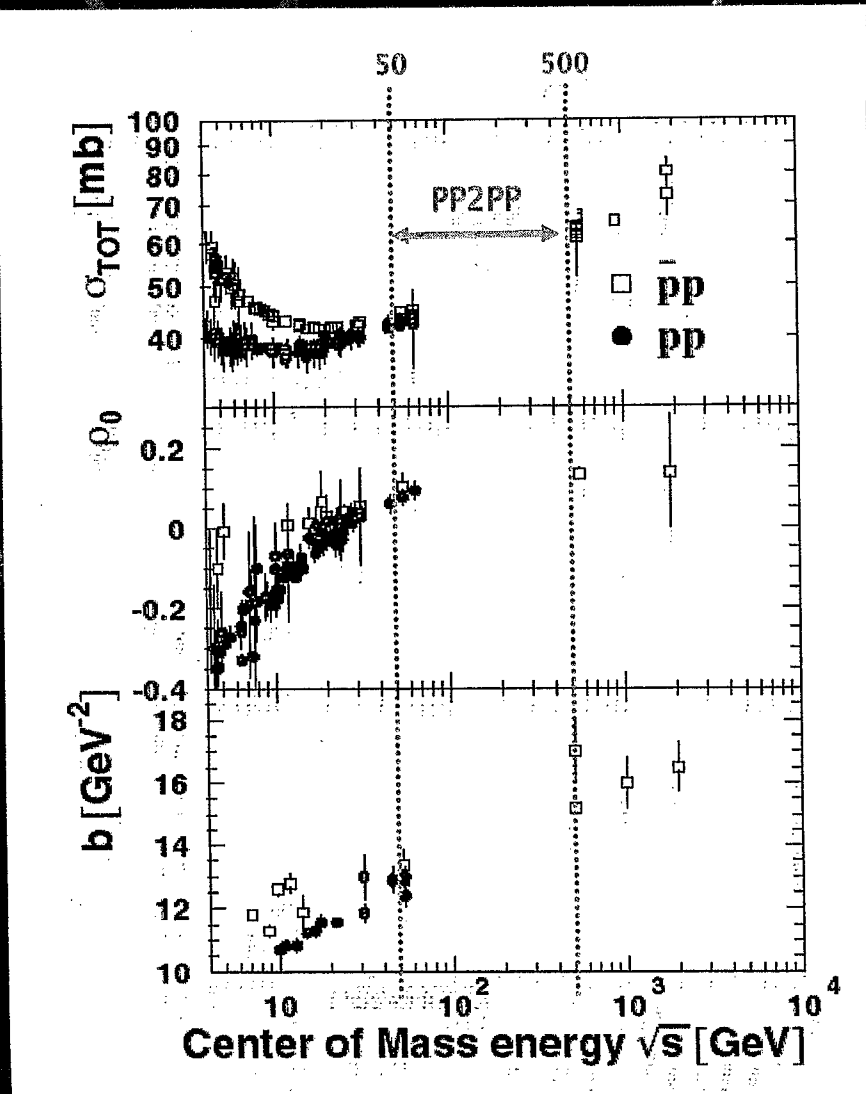
pp2pp $|t|$-range (at $\sqrt{s} = 500$ GeV)

$4 \cdot 10^{-4}$ GeV$^2 \leq |t| \leq 1.3$ GeV^2

Measured so far

$7 \cdot 10^{-3}$ GeV$^2 \leq |t| \leq 0.02$ GeV^2

(at $\sqrt{s} = 200$ GeV)



Scenario 1: No Upgrade

Change beam tune from $\beta^* = 10$ m to $\beta^* = 20$ m

- Access lower $|t|$-region of $0.003\ \text{GeV}^2 < |t| < 0.02\ \text{GeV}^2$
- Reduce beam size at Roman Pot stations

Extend energy range interesting

Physics Goals :

Measure A_N over extended $|t|$-range and at different energies

Measure A_{NN} (need high statistics, polarization)

Measure ρ and σ_{tot}

Scenario 2: Large β^*

Install new power supplies for magnets and change beam tune to $\beta^* = 70$ m

- Extend $|t|$-region to $4 \cdot 10^{-4}$ GeV$^2 < |t| < 0.12$ GeV^2
- Reduce beam size at Roman Pot stations

Extend energy range

Physics Goals :

Measure A_N in $|t|$-range encompassing its maximum allowing fit to address possible hadronic spin-flip contribution

Measure A_{NN} (Pomeron /Odderon contribution to amplitude)

Measure σ_{tot} directly in Coulomb region (do not need $\mathbf{L}$)

Improve ρ measurement by fitting in larger $|t|$-range

Scenario 3: High $|t|$

Add Roman Pot Stations between DX and D0 magnets

- Extend $|t|$-region up to 1.3 GeV^2

Physics Goals :

Measure A_N

- Sign change in the dip region
- Pomeron contribution to spin-flip predicted to cause large analyzing power at high energies

Measure in dip region above 1 GeV^2

- Difference between pp and $\overline{p}$p scattering (Odderon contribution)

AGS: Lessons from Run-3, What is in the works for Run-4?

L. Ahrens, BNL

June 20, 2003

for

RHIC Spin Collaboration Meeting XVII

RIKEN BNL Research Center

•The 2003 Polarized Run - the AGS Story

•Team: (Mei, Haixin, Christoph, and Vadim)(also RHIC) +(Kevin, Kip, Nick)(also NSRL),

• + (Leif , Woody, and Steve) +(Operations, rf, …)

•

•First beam (mode switching against Au-d) in late January.

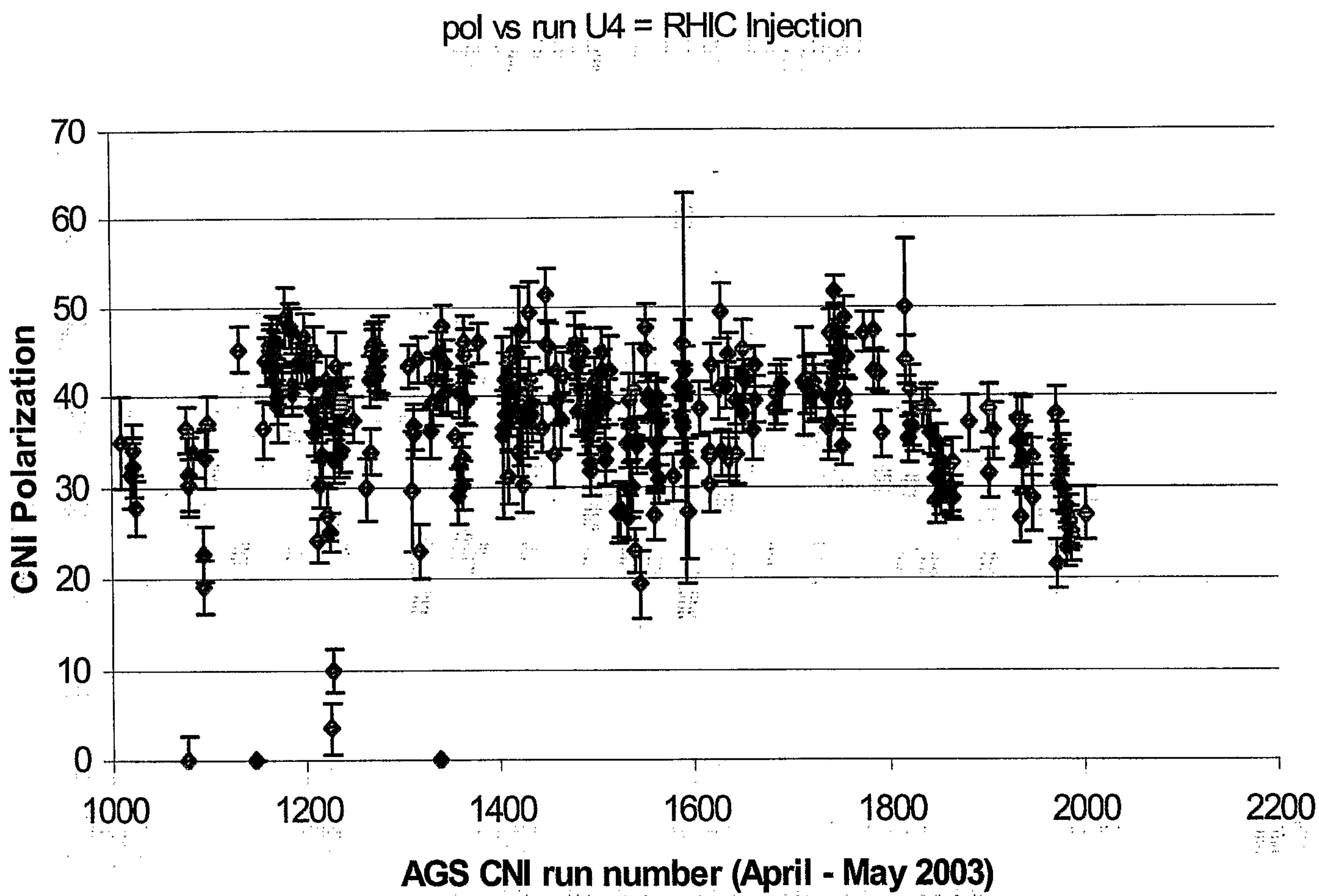
•

•Then mid February till the end of March mode switching behind RHIC Au-d filling.

•Then continue behind P^ in RHIC, with simpler context switch in AGS, but using all four AGS Users.

•

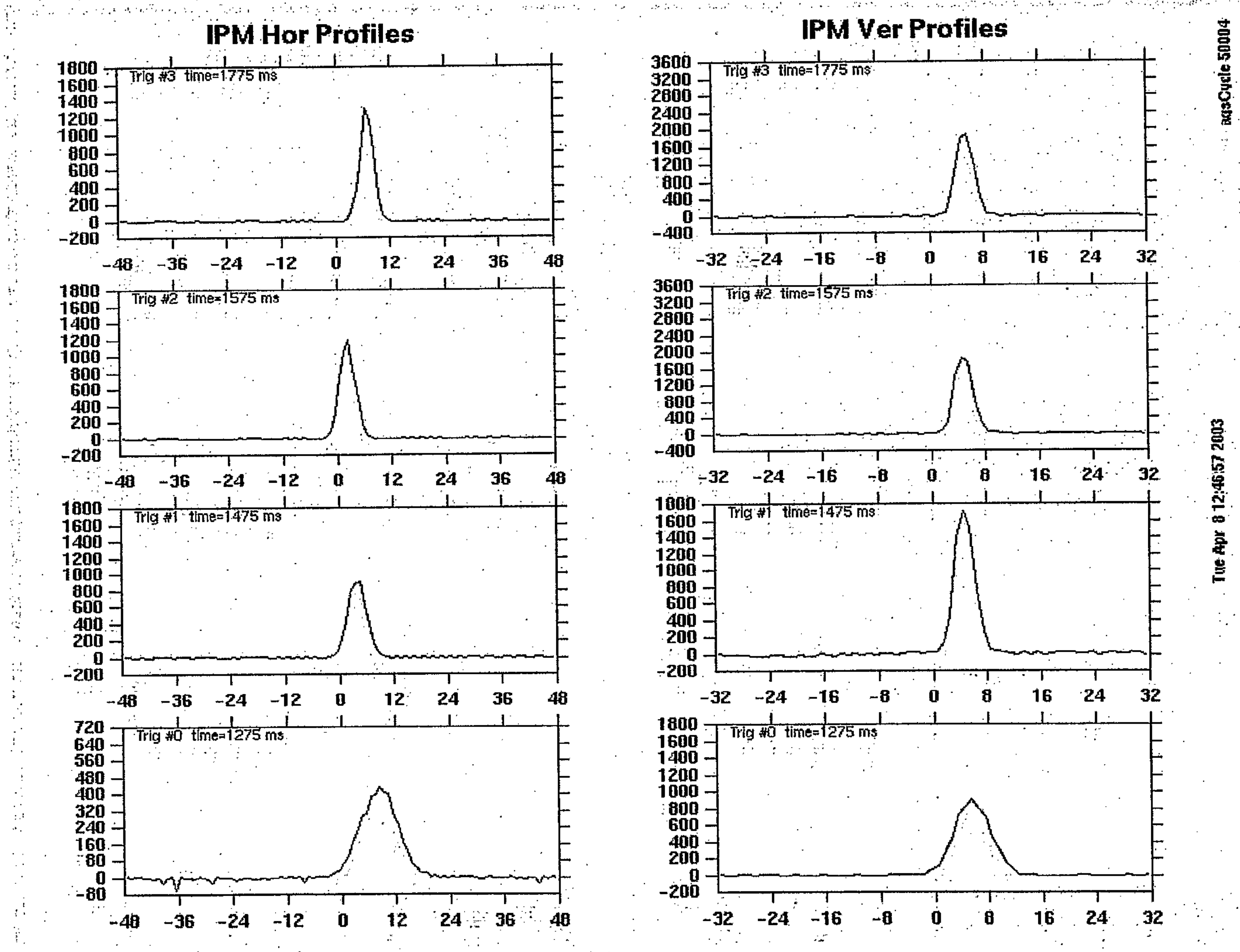
•40% polarization at $G\gamma = 46.5$ (RHIC injection energy) was achieved “easily” - little polarization-based tuning required – only for Booster $G\gamma = 4$ imperfection.


pol vs run U4 = RHIC Injection
CNI Polarization
0
10
20
30
40
50
60
70
1000
1200
1400
1600
1800
2000
2200
AGS CNI run number (April - May 2003)

We have a fine source: (Anatoli) 5e11 protons with 75% polarization available from the Linac at 200 MeV for each Booster Batch (= RHIC fill)

This gives us enough beam to allow shaving vigorously in all planes (longitudinal, vertical and horizontal)– to meet RHIC specs and beyond. With this and Zeno's semi-empirical Booster injection tuning and scraping strategies we typically worked with 6π 95% normalized emittance vertically beam in AGS. And also small (12π) horizontally.

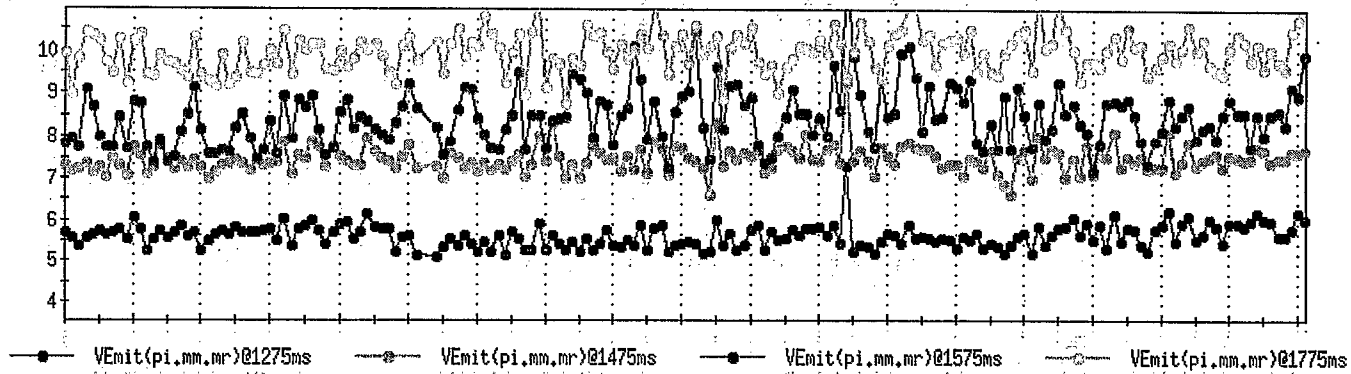
IPM Profiles

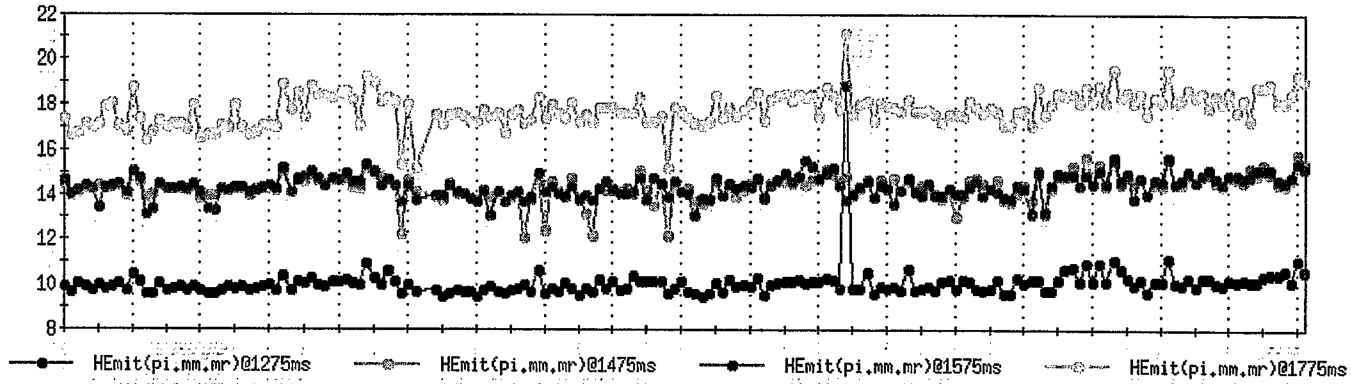


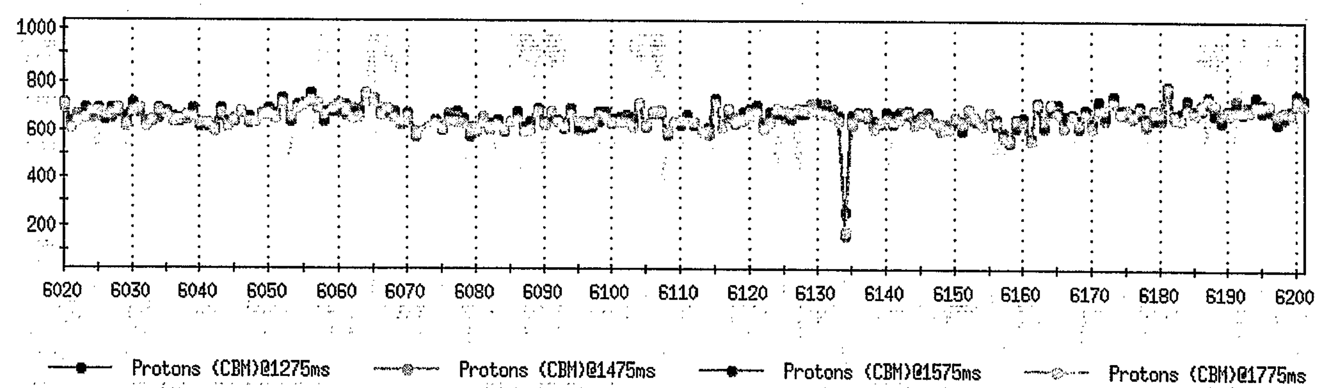
Agslpm PPM User: RHIC_PolProt_U4

SetupAcq DfltDisplay Configure Lib Analysis Help

IPM Processed Data







Acquisition Single-Cycle

Continuous Acquisition Single-Cycle

Acquisition Multi-Cycle

Continuous Acq/Log Single-Cycle

Reset StripCharts

Mon May 12 15:05:01 2003

Cen(mm)	H	V
1775	9.01	5.54
1575	5.34	5.09
1475	4.33	5.41
1275	13.12	7.69

Sig(mm)	H	V
1775	1.51	1.18
1575	1.58	1.24
1475	1.83	1.39
1275	4.33	2.69

	CBM
1775	57
1575	56
1475	62
1275	80

Emitnce	H	V
1775	16.52	10.05
1575	12.94	7.95
1475	11.76	6.80
1275	14.53	5.61

Trig	Cnt	Mean H Emit
1775	632	17.53 +- 0.88
1575	631	14.25 +- 0.67
1475	629	14.29 +- 0.61
1275	634	10.08 +- 0.88

Trig	Cnt	Mean V Emit
1775	632	9.77 +- 0.54
1575	631	8.16 +- 0.65
1475	629	7.37 +- 0.33
1275	634	5.64 +- 0.43

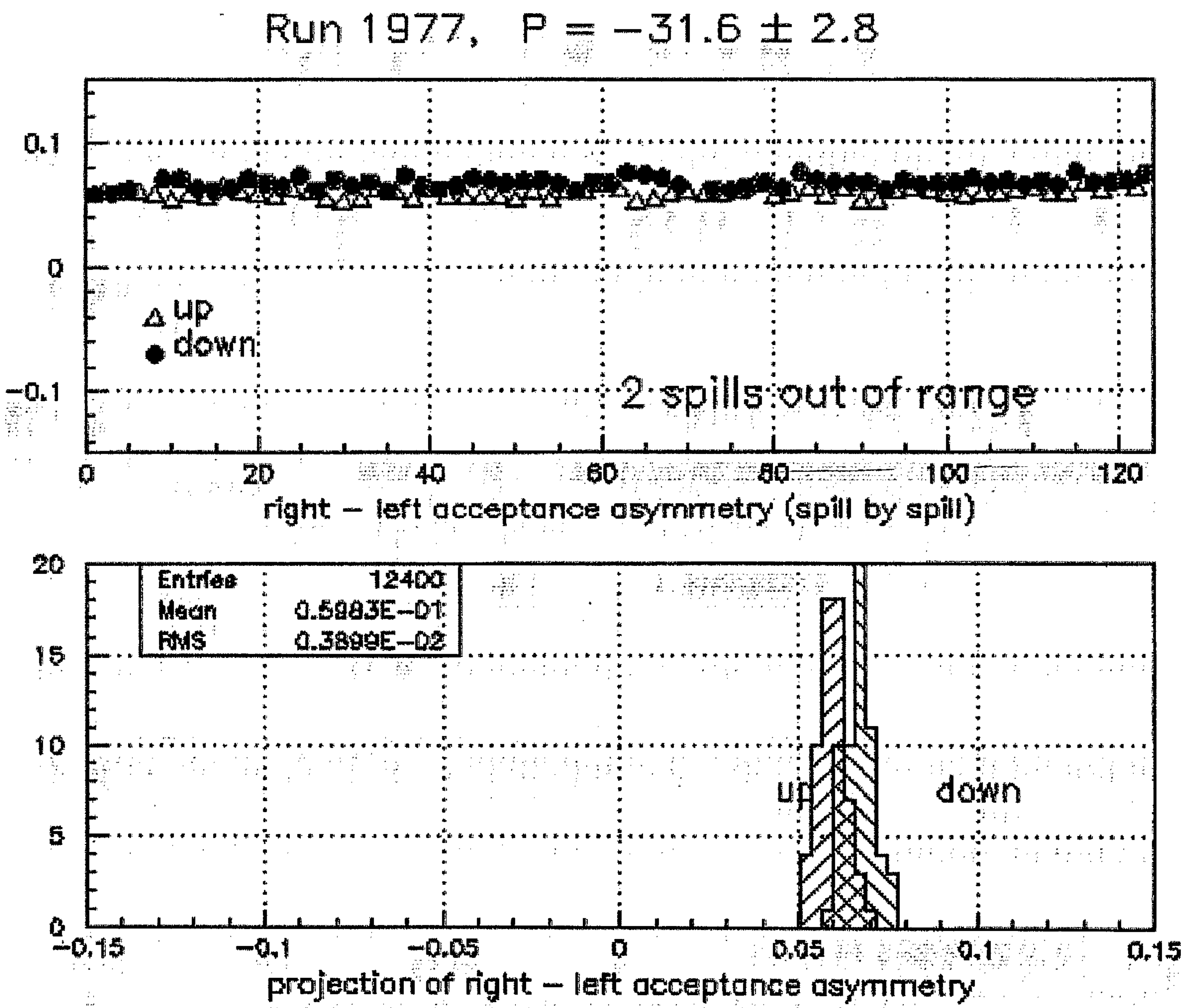
We have a fine new AGS polarimeter the AGS CNI polarimeter

(and a fine older one "E880" for checking):

With the CNI, one measurement at 46.5 takes about 6 minutes for 2.5% error in polarization. That error is fine to learn that systems are working – which is wonderful. However this error is not small enough to do "tuning". We need at least a factor of 2, but not by taking 4x the time.

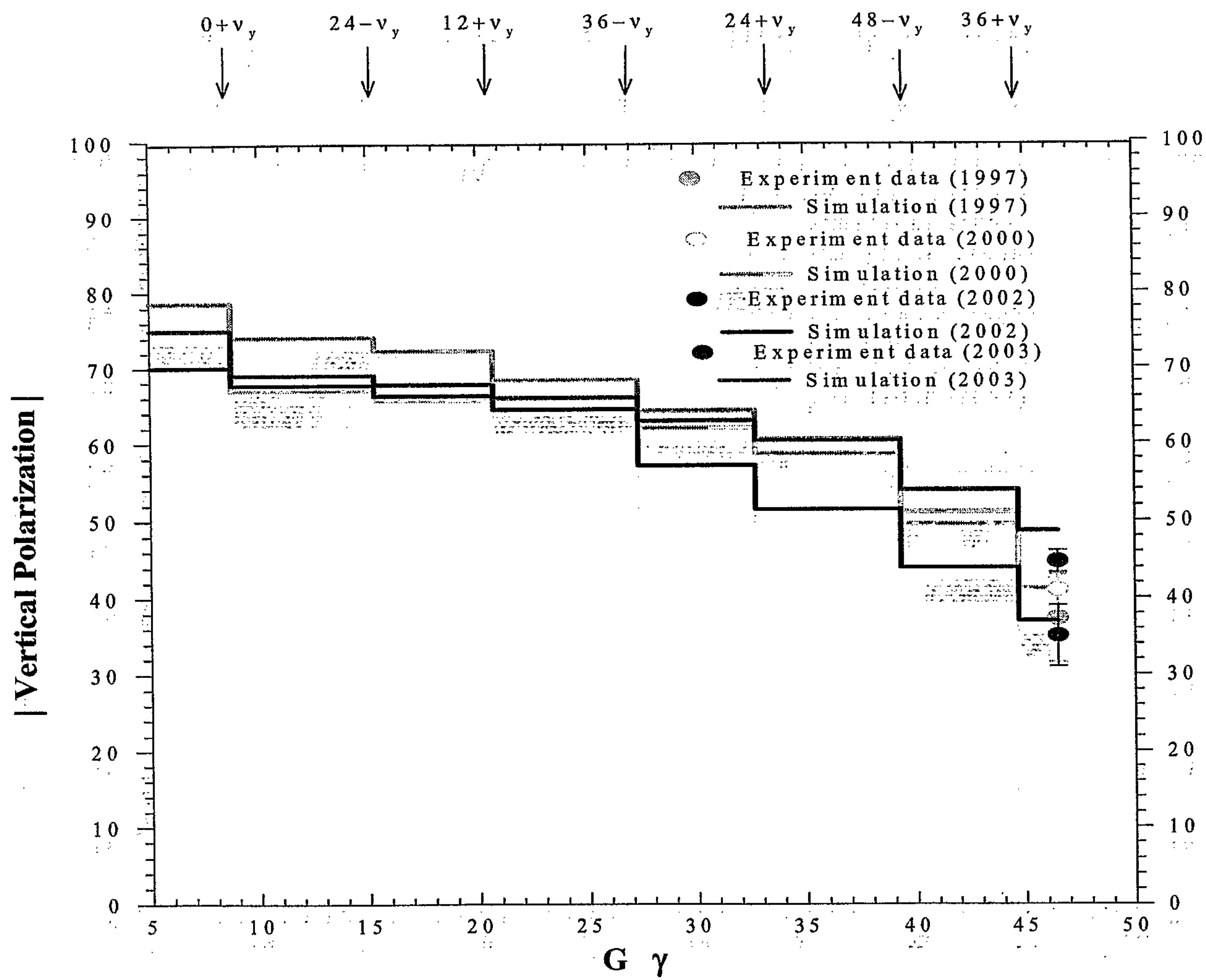
(however at the retreat Osamu promised x 20 next time if I understood – with a little help.)

Pics of some outputs at ggam 46.5 and 18.5

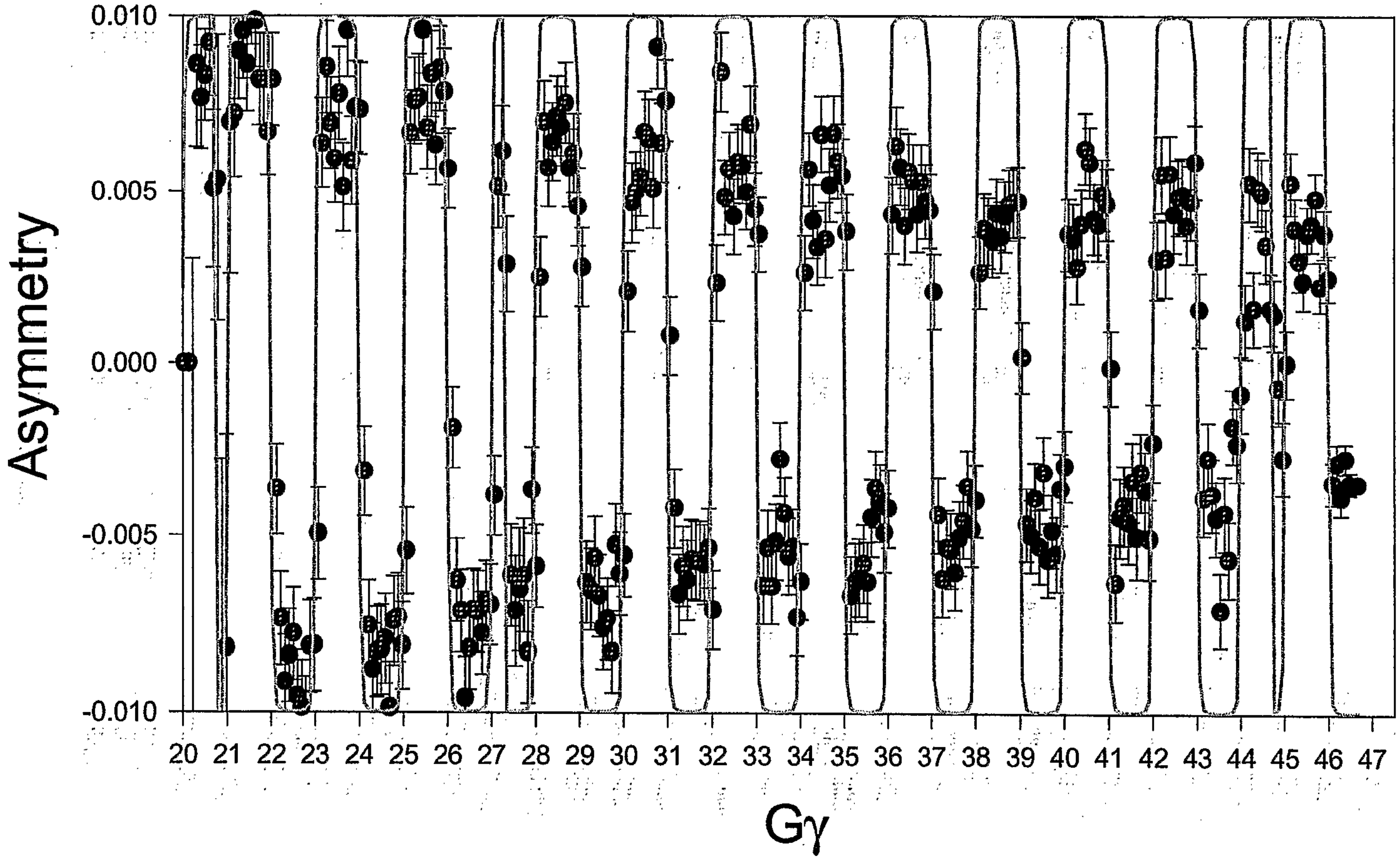

Run 1977, P = −31.6 ± 2.8
0.1
0
−0.1
up
down
2 spills out of range
0
20
40
60
80
100
120
right − left acceptance asymmetry (spill by spill)
Entries 12400
Mean 0.5883E−01
RMS 0.3899E−02
20
15
10
5
0
up
down
−0.15
−0.1
−0.05
0
0.05
0.1
0.15
projection of right − left acceptance asymmetry

We have a model for polarization survival in AGS:

(pic: Haixin's plot of pol vs energy)



We even can imagine filling in the steps:

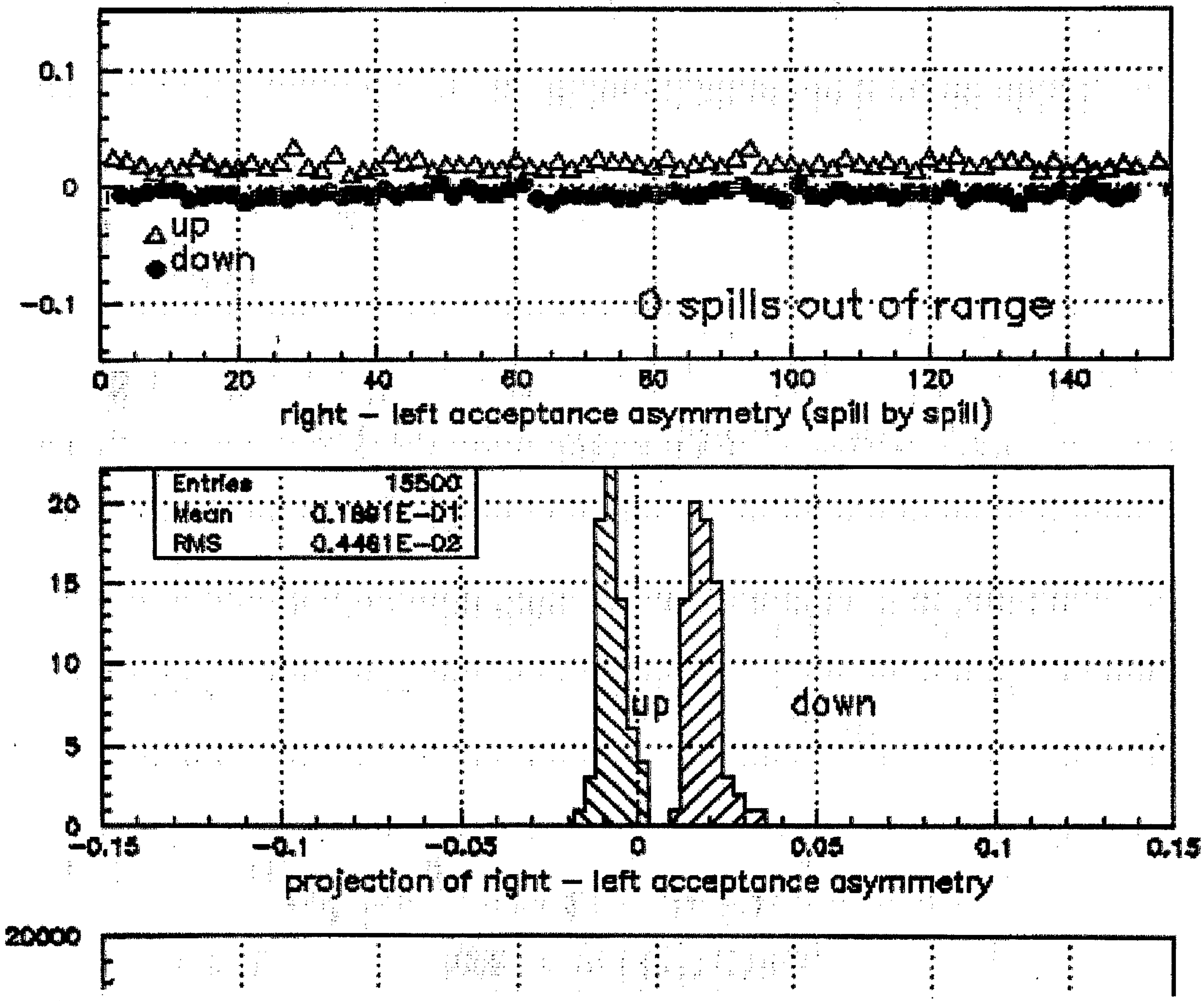


Osamu's pic from Tuesday (retreat) (Jeff Woods data analysis)
" Up-the-Ramp" measurement.

To make this more useful quantitatively we need model of cni polarimeter analyzing power "up the ramp".

To this end we measured at several lower energies during this run, with simultaneous measurements using E880.

Run 1962, "P" = 118.9 ± 3.1 @ Gγ = 18.5



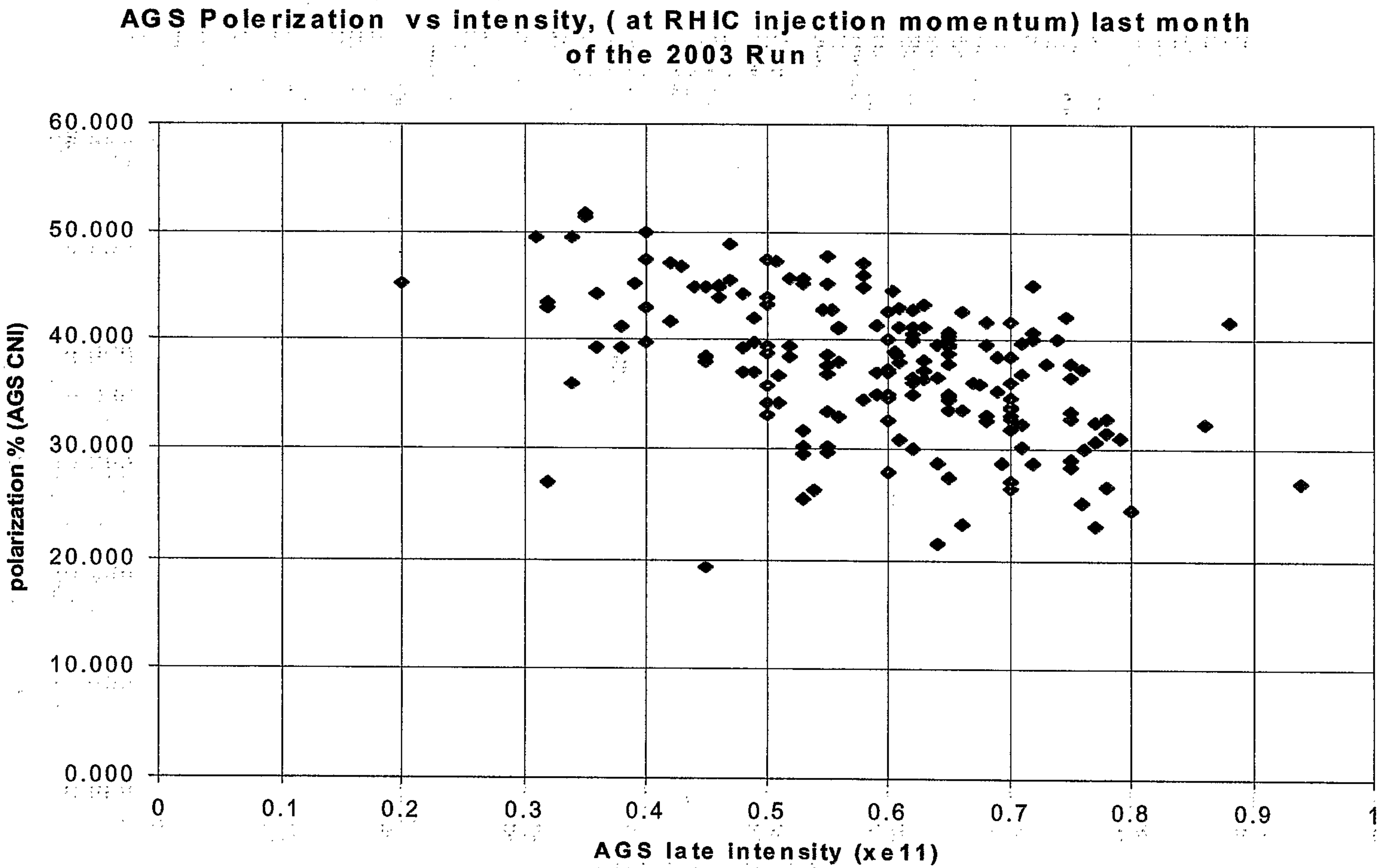
A significant part of the predicted losses come from resonances made strong by the solenoidal partial snake. The plan is to add a helical warm snake this summer to get rid of this source of coupling.

We do have problems – perhaps small perhaps large:

Systematic improvement beyond 40% did not occur – we predicted better than 50%.

Polarization variation cycle-to-cycle(?) (run #1977 again). More statistics will help. Also data correlation tools. The CNI polarimeter is only partially integrated into the controls system.

And there is possibly some intensity dependence to the polarization … which we do not expect



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So what else to do next?

Is the ac dipole strong enough? Ongoing discussion – some interesting data.

Something was going sour over the last couple of days of the run. What? (ongoing search).

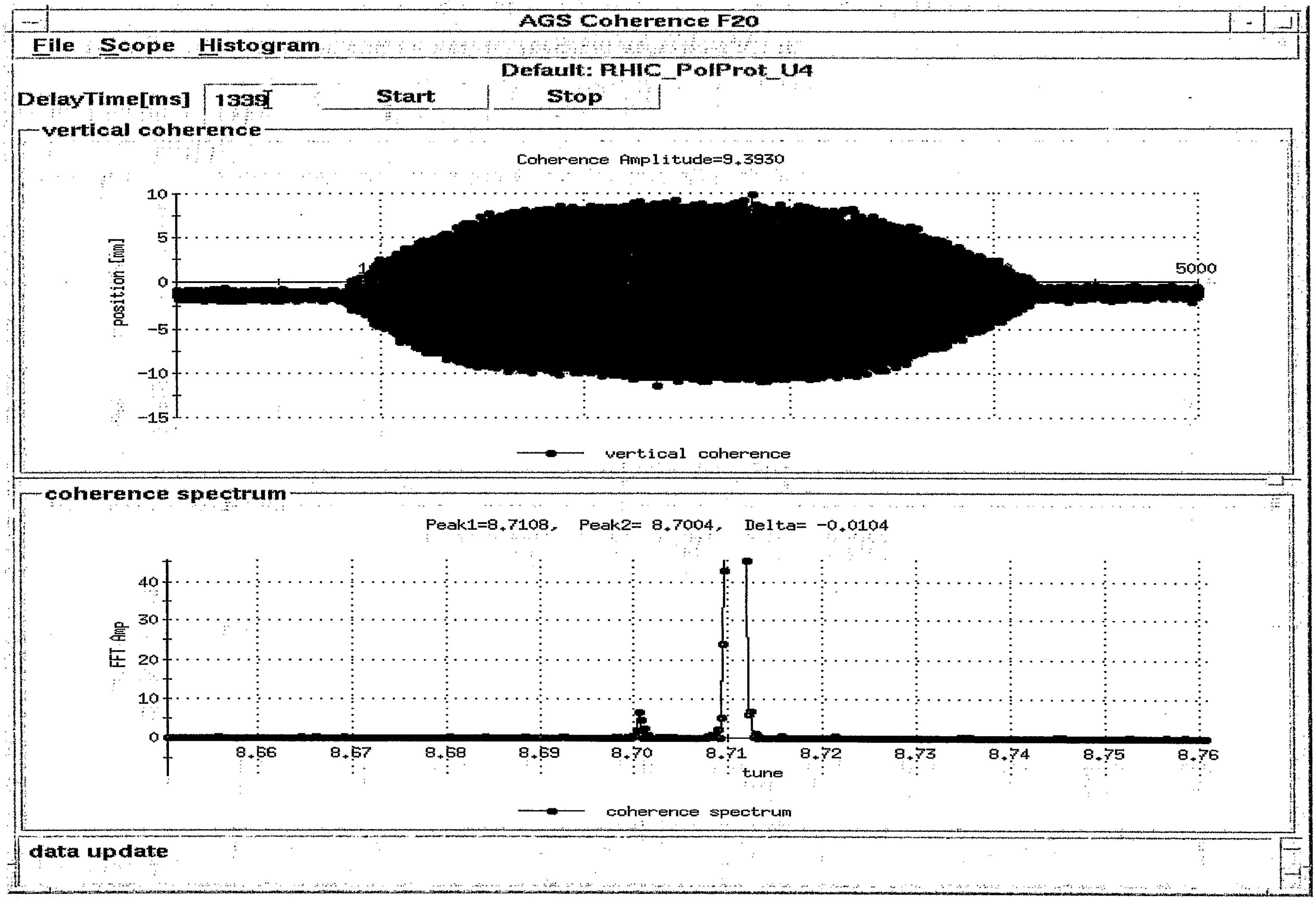
The diagnostics appear to work. We need easier methods for data collection to see. More automated systems for collecting Gauss clock, rf frequency, emittance, ac dipole coherence, … measurements.

Transverse emittance was excellent, but can be even better. Measurements of the effect of staying on the injection foil for the long pulse length showed emittance growth (using multiwires in BtA). The foil is optimized for efficiency when we are running high intensity. A thinner foil will be added for polarized running (Depak Raparia , Kip, Keith (Zeno)).

The equilibrium orbit tools and the magnet positions in AGS are a bit rusty. Work for the summer – vertical survey and repositioning, bpm survey and data reduction to improve the information coming from this system.

Possible AGS sextupole problem (Woody's measurements). About this we will soon learn.

A well-behaved ac dipole pulse (at 0+)



RHIC Polarized Protons Operation 03

Haixin Huang

RSC meeting June 20,2003

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Chronology of pp Run

Mar 26	**pp commissioning started**	
Apr 1	**Polarized source down**	**Polarization tuning along ramp hindered**
Apr 4	**Polarized source back on**	
Apr 7	**Polarimeter worked**	
Apr 8	**Deliver collision at β^*=2m**	**Hard to steering collisions**
Apr 12	**Deliver collision at β^*=1m/3m**	**Background is an issue**
Apr 15	**y09-snk7-2.3 failed**	**Caused three days delay**
Apr 16-17	**2-day access**	
Apr 18	**Snake bumps in**	
Apr 19	**Reduce intensity pilot bunch**	
Apr 20	**Collision with 1+0.88 snake**	**Blue:51.7+-4%->41+-2%**
Apr 22	**Start commissioning IR 8 rotator**	**Had hard time on Yellow polarization**
Apr 29	**Change Yellow snake setting**	
May 3	**Start physics run**	
May 15	**IR 6 rotator commissioned**	
May 18	**RF cavity window failure**	**Caused one day delay**
May 19-21	**pp2pp special run**	
May 23	**Switch to 2 IR**	
May 30	**Run ended**	

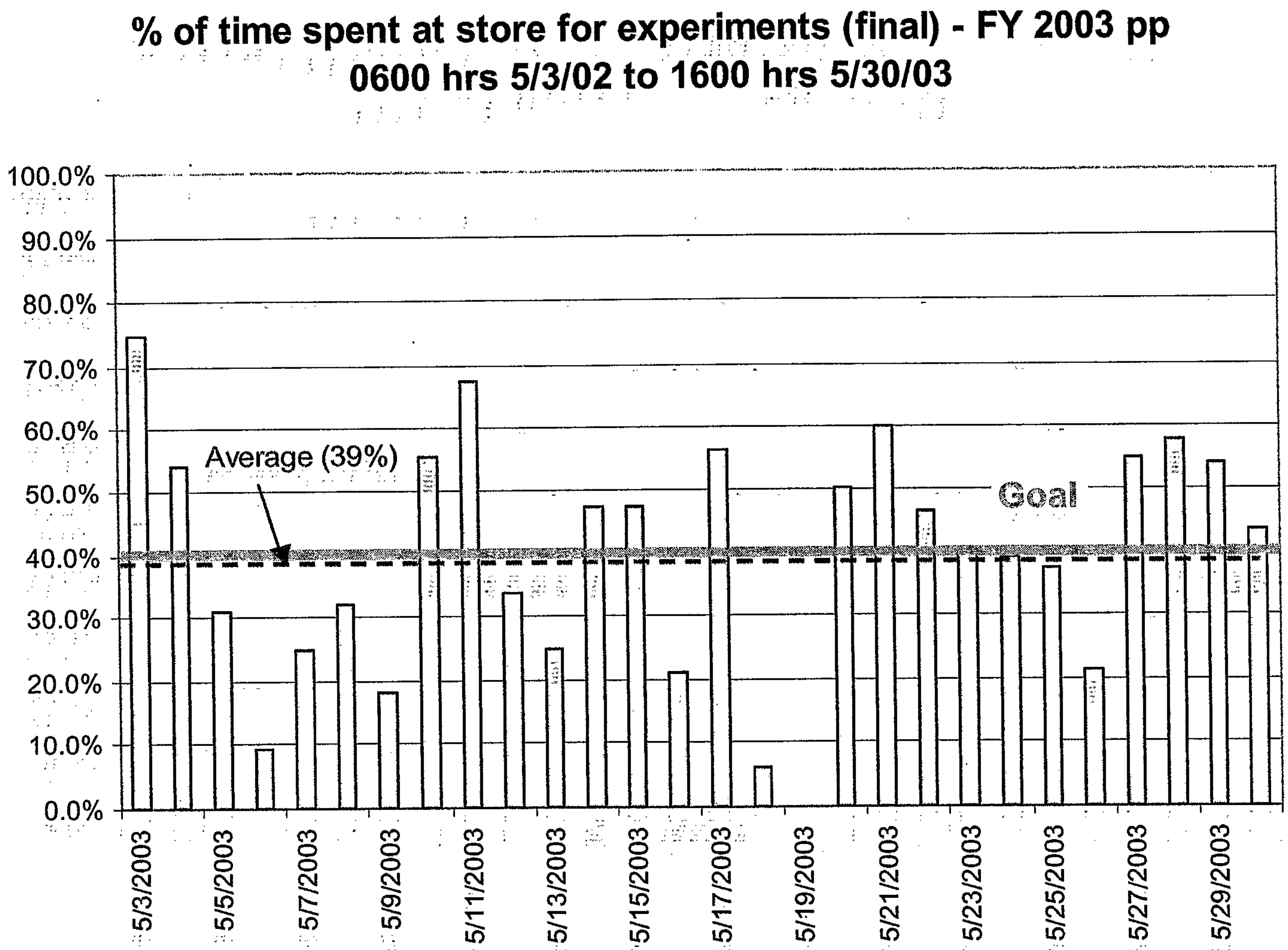
RHIC FY03 pp Performance Goals

Machine Performance	goal	achieved
Intensity/bunch	1.0×10^{11}	0.65×10^{11}
Polarization	40-50%	30-35%
Transverse Emittance [95% $\pi\mu$rad]	25	15
Peak luminosity L [$\times 10^{30}$ cm^{-2} s^{-1}]	16	6
Machine efficiency	40%	39%
Setup/Ramp-up time [weeks]	2/3	2/3.5
Storage Energy [GeV/u]	100	100
Number of bunches	110	110/55
β^* [m]	1/3	1/3

Status and Achievements

- Source polarization ~70-75% most of time, it is reasonably stable.
- AGS provided ~40% polarization through the physics run.
- Spin rotators commissioned successfully. Longitudinal polarization for the first time at IR 6 and 8.
- Yellow ring maintained polarization with one snake crippled (we saved the run!)
- 55 bunches per ring with 0.65×10^{11} p↑/bunch, emittance ~15 π, Beam polarization ~ 30-35 %
- $\beta^* = 1$m at IR 6 and 8.
- Peak luminosity at beginning of store: $\sim 6 \times 10^{30}$ cm^{-2} s^{-1} (preliminary) at 100GeV
- Observed instability along ramp with higher intensity
- Beam life-time affected by beam-beam effect. Working point has to be accurate at 0.001 level.

RHIC Efficiency



Why Not 110 Bunch?

1.One key issue is rf frequency lock. Without it, beam still see each other on the ramp and we could not ramp reliably. It is running properly at the later part of the run.

2.Vacuum pressure rise with higher intensity.

3. Injection beam loss.

4. The ramp was set up in such a way that separation bumps were removed gradually during the beta squeeze part of ramp. To run 110 bunch (or somewhere between 55 and 110), we have to keep separation bumps on (anti-cogging does not work for 110 bunch mode). In last a few days, items 1-3 went away for low intensity beam, but we could not retune ramp easily.

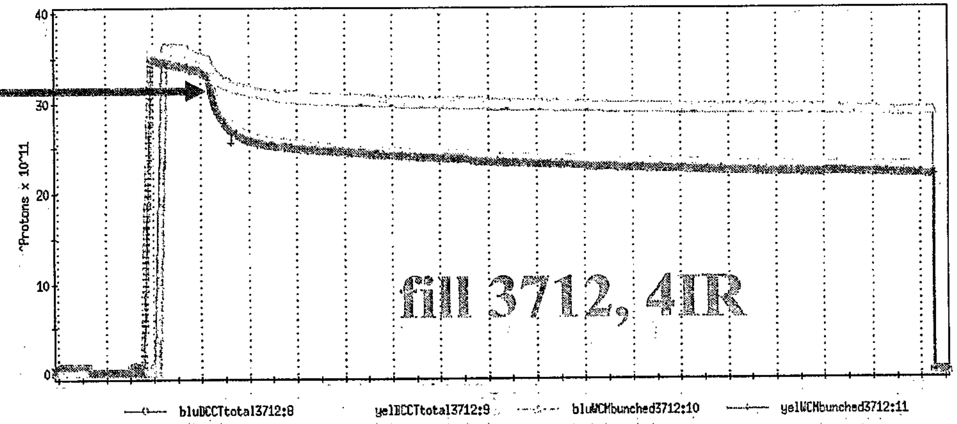
Luminosity

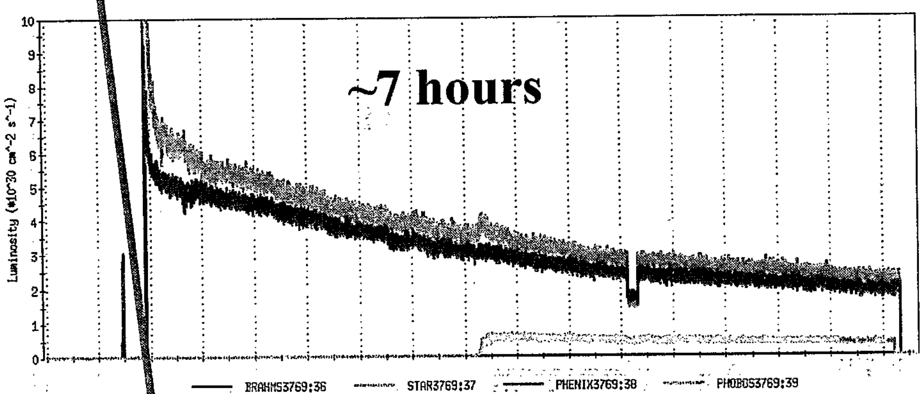
Two main reasons to have about the same luminosity as last year while β^* is three times smaller:

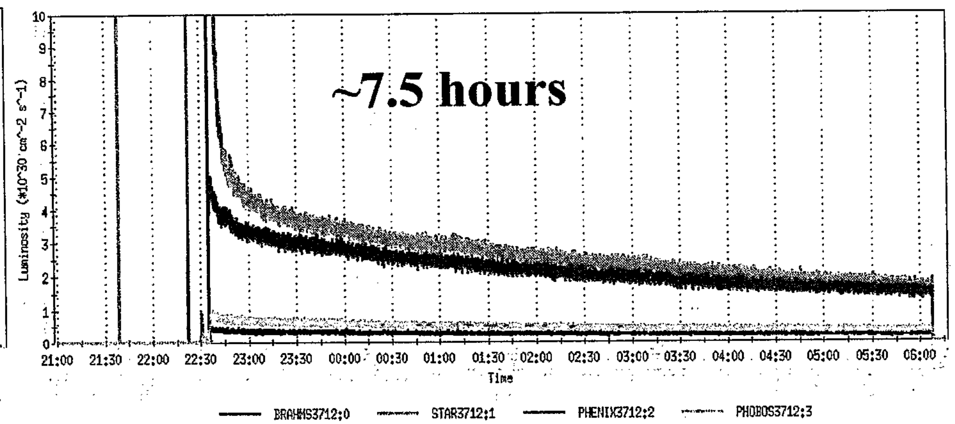
1. Intensity usually was smaller by a factor 1.3
2. Nonlinearity more significant this year due to 1m β^*. Worse life time.

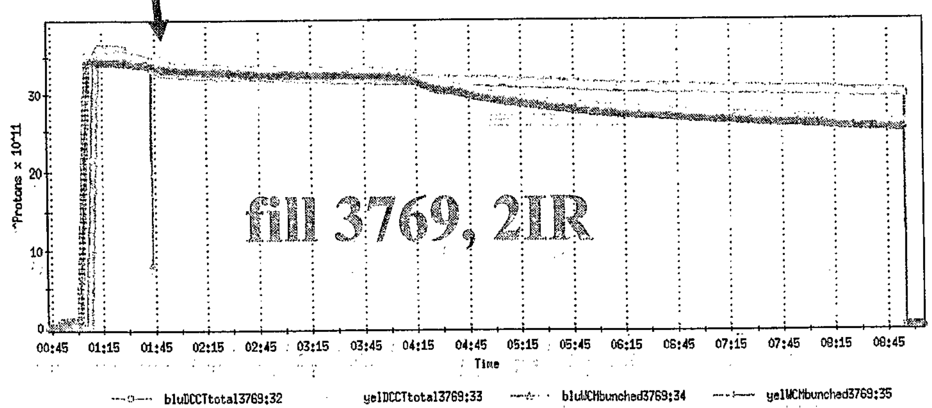
4 IR vs 2 IR

Beam-beam causes emittance blow-up and even beam loss.
Beam-beam is not a hard limit but very much dependent on how well the working point is set.









Compromise: Set up collision for IR 2 and 10 after luminosity drops by a factor 2?

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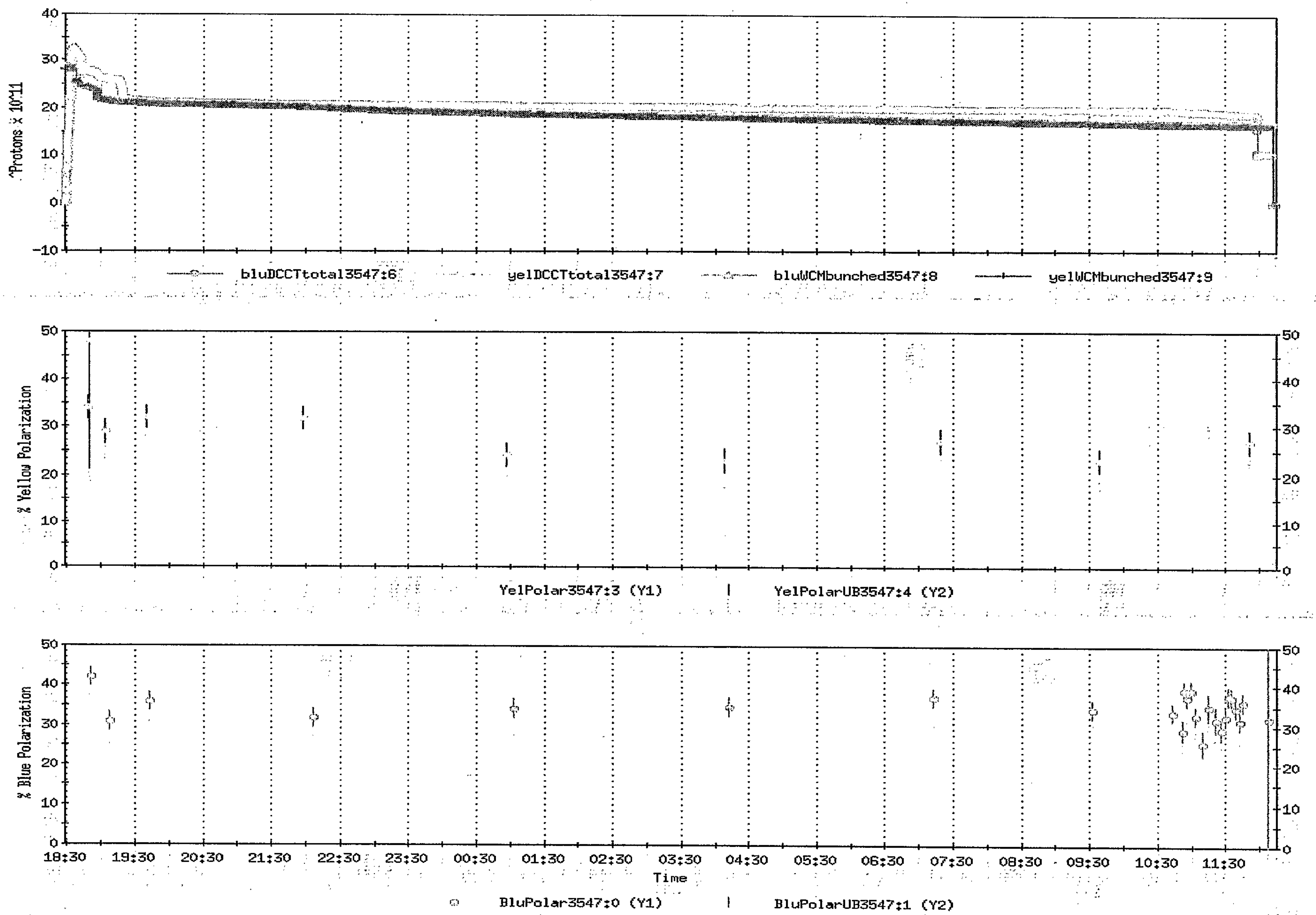
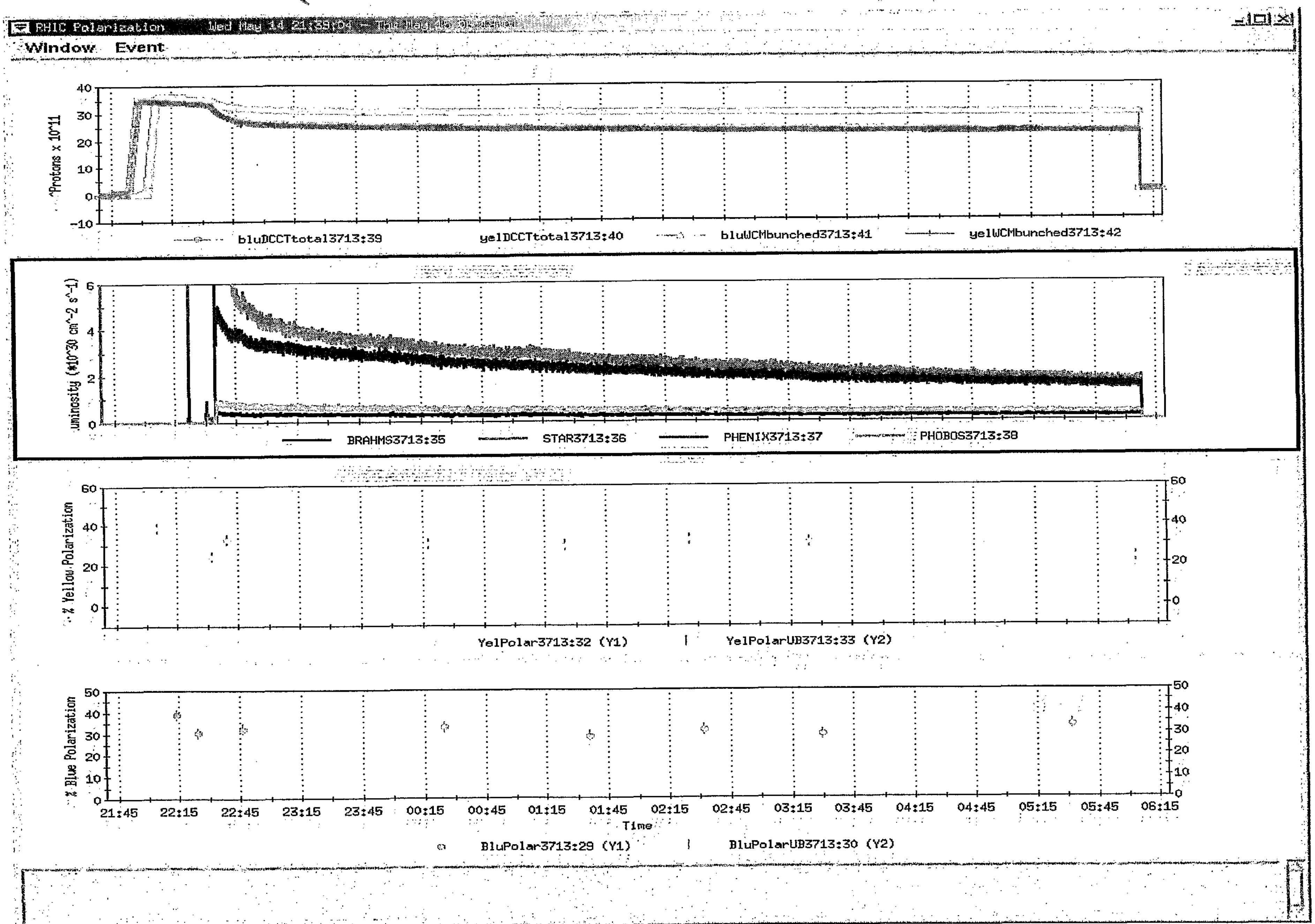
Fill 3547(IR 8 at radial polarization)



Fill 3713 (before IR 6 rotator on)



RHIC Polarization Set-up

- The vertical tune was chosen at 0.23, between 2 high-order spin resonances:
  - 1/4=0.25 ; depends on vertical orbit
  - 3/14=0.2143; exists even without orbit errors

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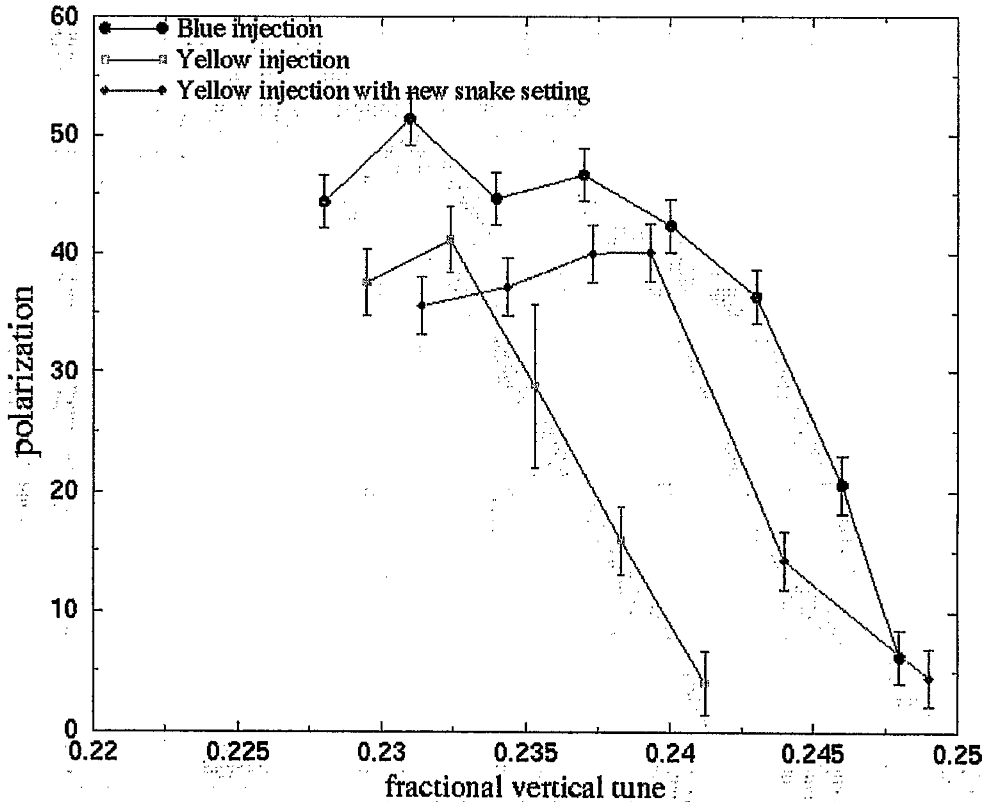
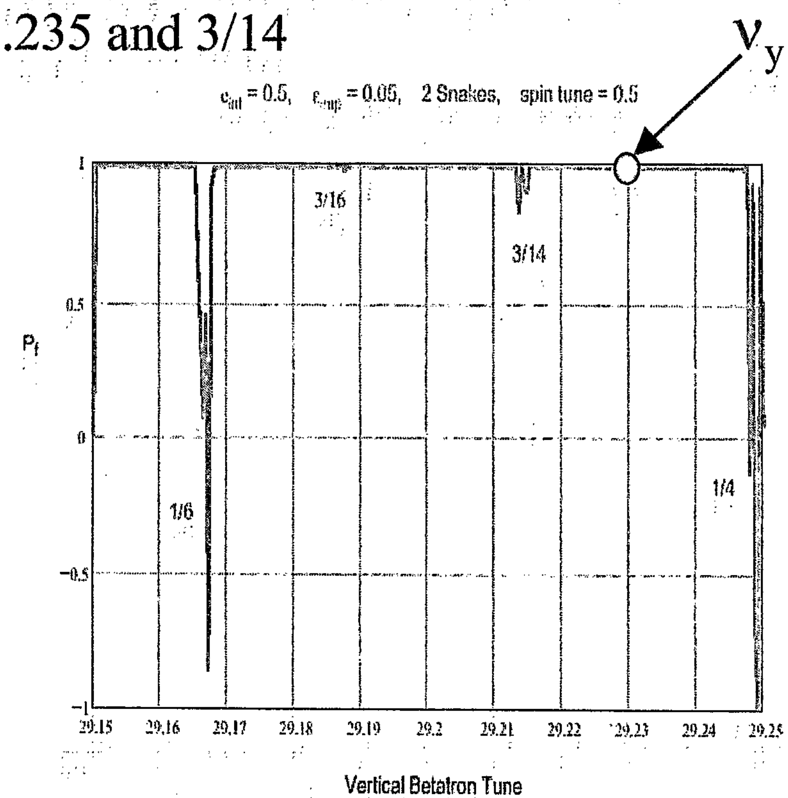


Keep the vertical tune between 0.235 and 3/14



Snake Resonances

$$\nu_{sp} = k \pm n\nu_y$$

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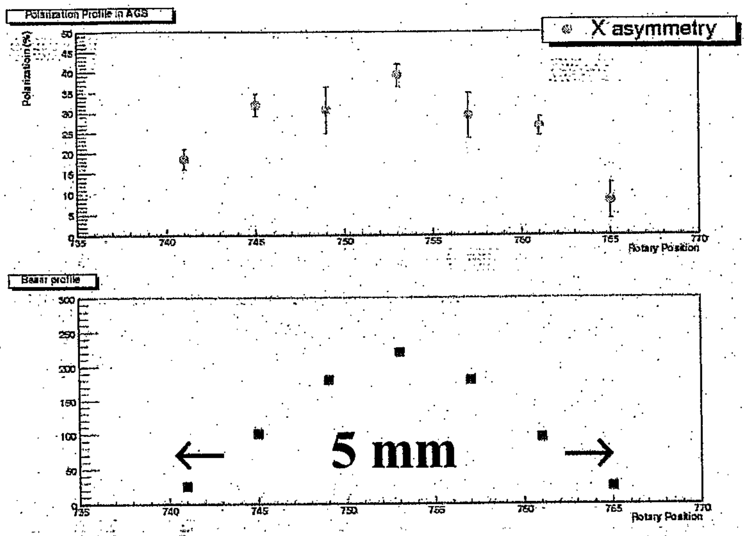
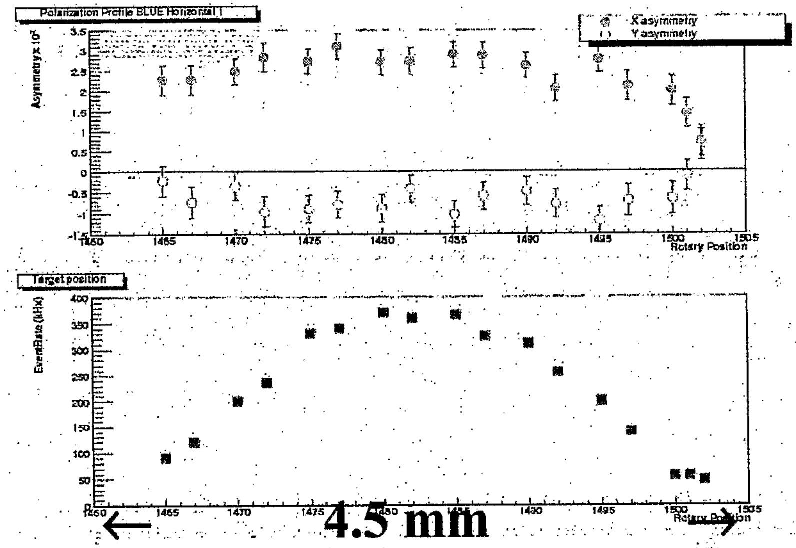
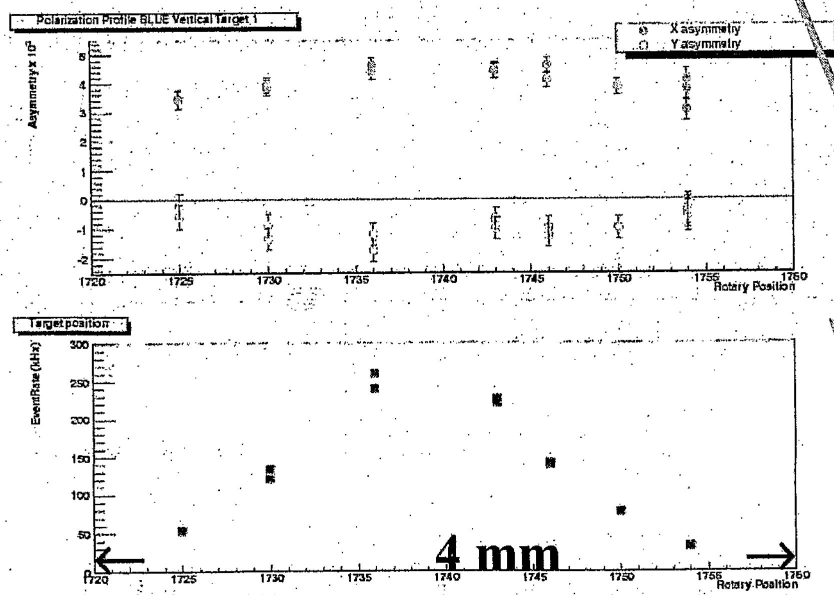
Polarization Profile at End of Store (Blue)



AGS extraction



Vertical



No strong dependence of polarization along beam profile at the end of store. But AGS extraction shows stronger dependence across the beam profile. We should measure polarization profiles in the beginning of a store next run.

Horizontal

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Polarization

- Very little polarization loss for energy ramp part. Most polarization loss was during beta squeeze from 2m to 1m.
- There was more polarization loss in Yellow even before the snake failed.
- Large tune spread (chromaticity), coupling along the ramp were hard to tune out.
- Just using the rms orbit seems not enough to improve polarization: not always showing effect on polarization.
- For some fills, there seems to be a trend of polarization loss in Yellow during store. Possible reason: not two full snake in Yellow but no systematic study on it yet.
- Scan snake current setting and measure polarization to find the best setting for snake currents.
- Polarimeter systematic study is needed.

Lesson Learned

- Tuning injection with pilot bunch and vertical bump from beginning of commissioning (snake quenched about 20 times this year, much more than last time, partly due to 10 meter β^* at injection).
- Combine all ramp together as one ramp (energy ramp, beta squeeze, and rotator ramp).
- Control of experiment magnets by MCR? Some magnets still need local monitoring, such as PHOBOS.
- We should start 2 IR operation earlier.
- It is very hard to reach the luminosity/polarization goal with such a short run.
- We need spare rf tube for the polarized source.

Lesson Learned (2)

- **Operation error/ Procedure error contributed significantly to the down time. Need a task force to evaluate all significant failures and make sure we have protection for next run.**
  - polarimeter target moving into beam (procedure error)
  - BLM not activate in rotator ramp (procedure error)
  - set snake to wrong current (operation error)
  - many confusions for the separation bump on/ff on the ramp (configuration issue)
  - yellow 3.2 cavity window broken (operation error)
- **Ramp maintenance during physics run period (1-2 shift/week)**
- **6+2 (backup) shift leader schedule is a stretch to all shift leaders. We need more people to take shifts.**

Job List in the Tunnel for Next Run

- Repair Yellow snake (back to the tunnel on 09/10/03, installation done by 10/15/03)
- Replace Si detectors and broken targets (Given the fact we lost target once a week, it is expected to have target replacement once a month for future higher intensity: which means one day turn around time for vacuum pumping down. This is still under investigation)
- More magnet alignment based on current survey data
- Polarized jet target installation in the shut down and ready for commissioning

Job List (continued)

- Better beam control on the ramp is necessary
  - Tune feedback (PLL)

Tune feedback was not operational this year--- part of reason of polarization loss along the ramp. What are needed to bring it operational?
We need to commission tune feedback prior to pp run.

  - Improved orbit correction (below 0.3mm rms)

How much benefit we have from magnet realignment last year?

  - Coupling control on the ramps
- Intensity limitation due to vacuum pressure rise
  - for 110 bunch mode, need 12 bunch +8 gap
  - Scrubbing
  - Coating beam pipe
- Operating close to the beam-beam tune shift limit.
- Systematic analyze polarization for each polarization measurement

Post-run Data Analysis

1. Sort out all stores with different conditions which may hurt polarization: sort ramps from rms orbits

sort ramps from tunes (x,y) at a few strong resonances

sort ramps from tunes (x,y) during beta squeeze part

Compare polarization preserving efficiency (P_f/P_i) over ramps. This will be our base for simulation.

2. Simulation of polarization evolution on the energy ramp. Time consuming to do multi-particle simulation over the whole energy ramp, should concentrate at suspicious locations: gg64, gg104, gg179.

3. Simulation of polarization evolution of beta squeeze part.

4. Polarization profile simulation. Since we only have RHIC data at the end of store, it is hard to compare the data with ramp simulation in RHIC.

However, I think the profile is most likely due to the AGS profile, then it is relative easier to simulate (take less computer time).

RUN 4 Scenario

1. Beam-beam is certainly an issue for next run. We may need to invest more beam time to investigate the effect and ways to cope with it. Smaller transverse beam was used this time partially due to the limitation of AGS CNI polarimeter. Next run: set up AGS with 1-1.5*10^11/bunch and larger transverse emittance (20 pi) and run two IR only. The goal is to reach 10^11 at RHIC store.
2. Pressure rise issue probably can be avoided with 55 bunches. Scrubbing is promising and coating is going to help next year.
3. The polarization ratio between store and injection was about 0.8 at the best. We have done better with 10 m /2 m beta star (0.9-1). The reasonable hope is to reach 0.8 consistently.

RHIC Polarization

RHIC FY2002-2003 Retreat

Mei Bai, BNL, Upton, NY 11973

Spin Resonance

- Imperfection resonance

  $\nu_{sp} = n$ $\propto$ close orbit distortion

- Intrinsic resonance

  $\nu_{sp} = nP + \nu_y$ $\propto$ vertical beam emittance

- Coupling resonance

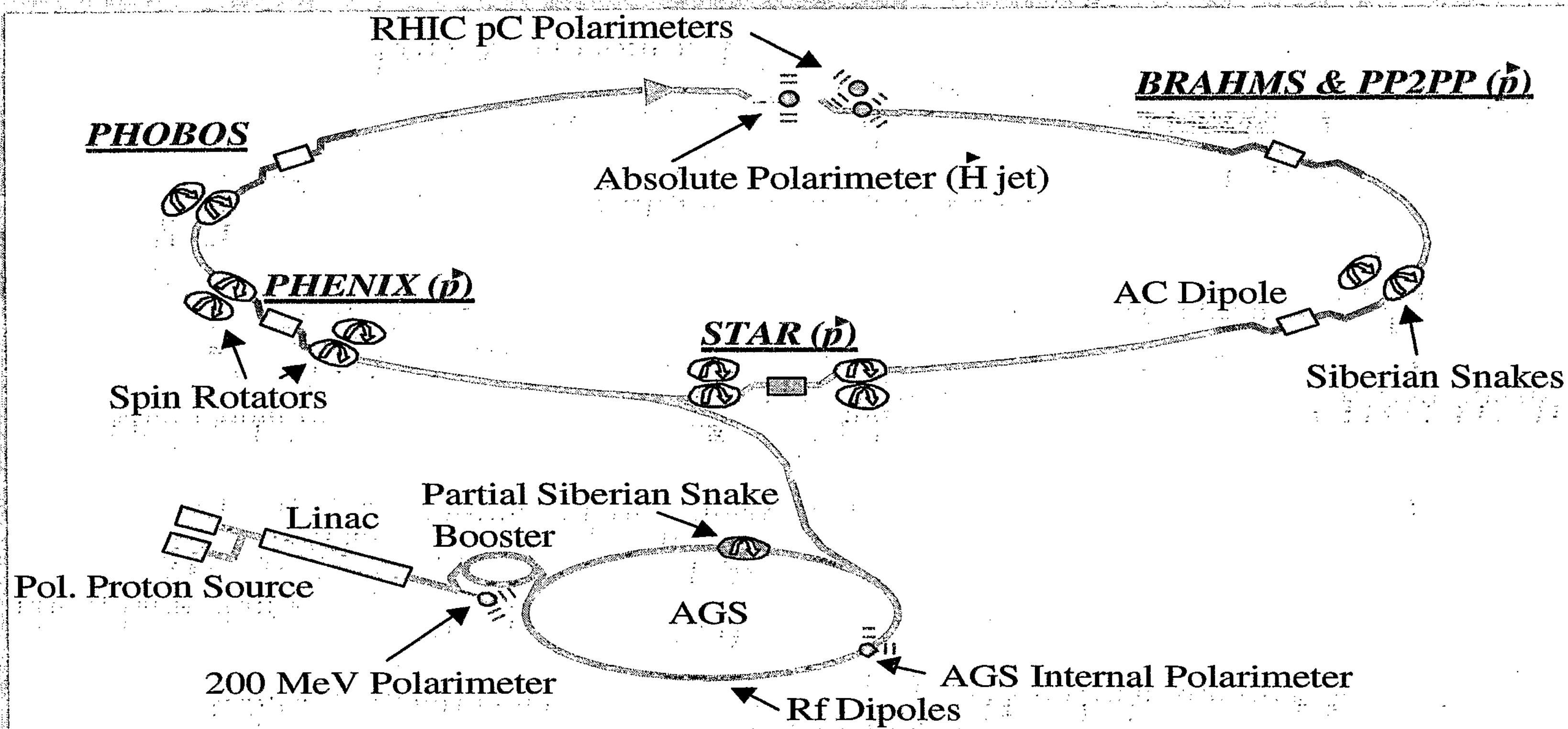
  $\nu_{sp} = nP + \nu_x$ $\propto$ horizontal beam emittance

- Snake resonance

  $\frac{1}{2} \pm n\nu_y = \text{integer}$ $\propto$ intrinsic spin resonance

  imperfection spin resonance

RHIC ↑Proton Acceleration Setup

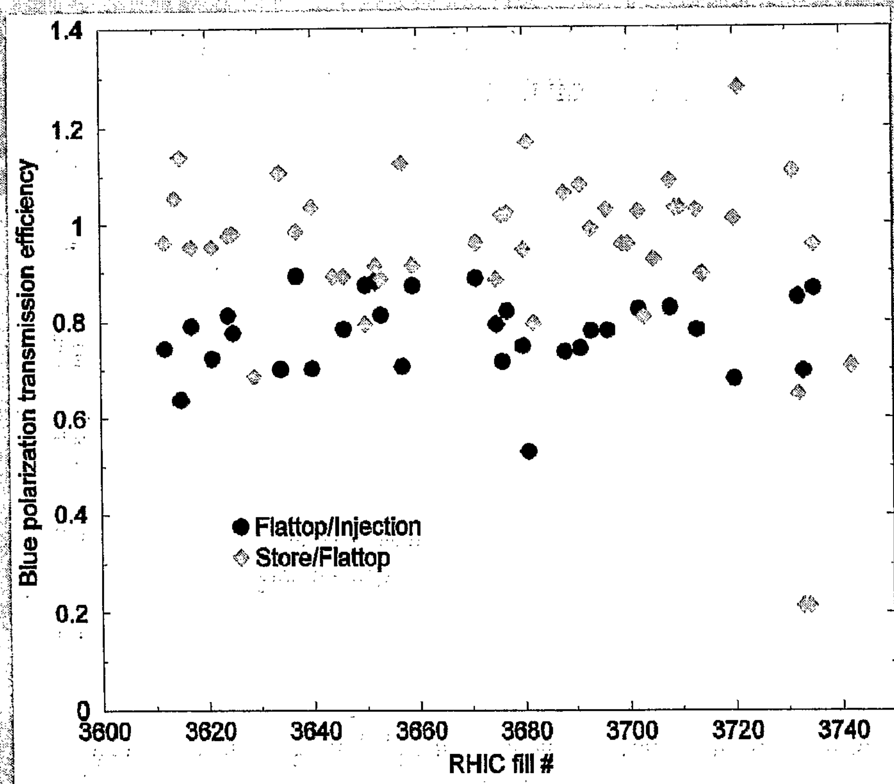


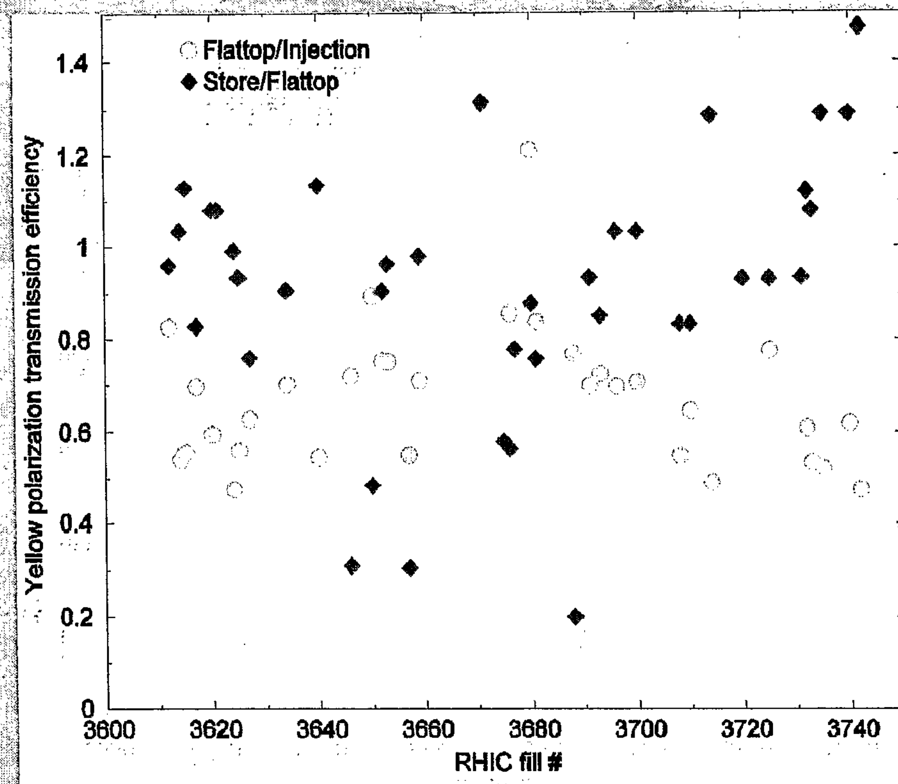
- blue ring
  - two full snakes
  - spin rotators at IP6 and IP8
- yellow ring
  - one full snakes + one 88% snake
  - spin rotators at IP6 and IP8

What did we accomplish?

Average polarization	Injection		Flattop		Store (after rotator ramp)	
	blue	Yellow	Blue	Yellow	Blue	yellow
β^*=1m@IP6&8 β^*= 3m @IP10&2	0.371	0.358	0.299	0.242	0.283	0.215
pp2pp	0.298	0.346	0.301	0.267	----	---
β^*=1m@IP6&8 β^*= 3m @IP10&2 no collision	0.309	0.296	0.238	0.226	0.190	0.205

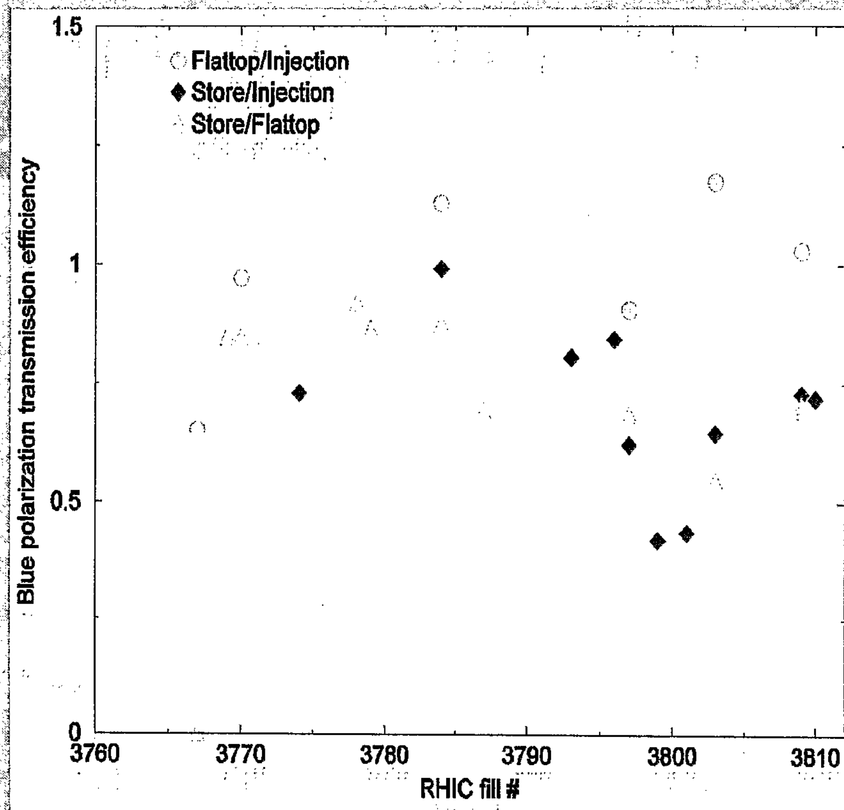
Polarization efficiency w 1m at IP6 and IP8, 3m at IP10 and IP2

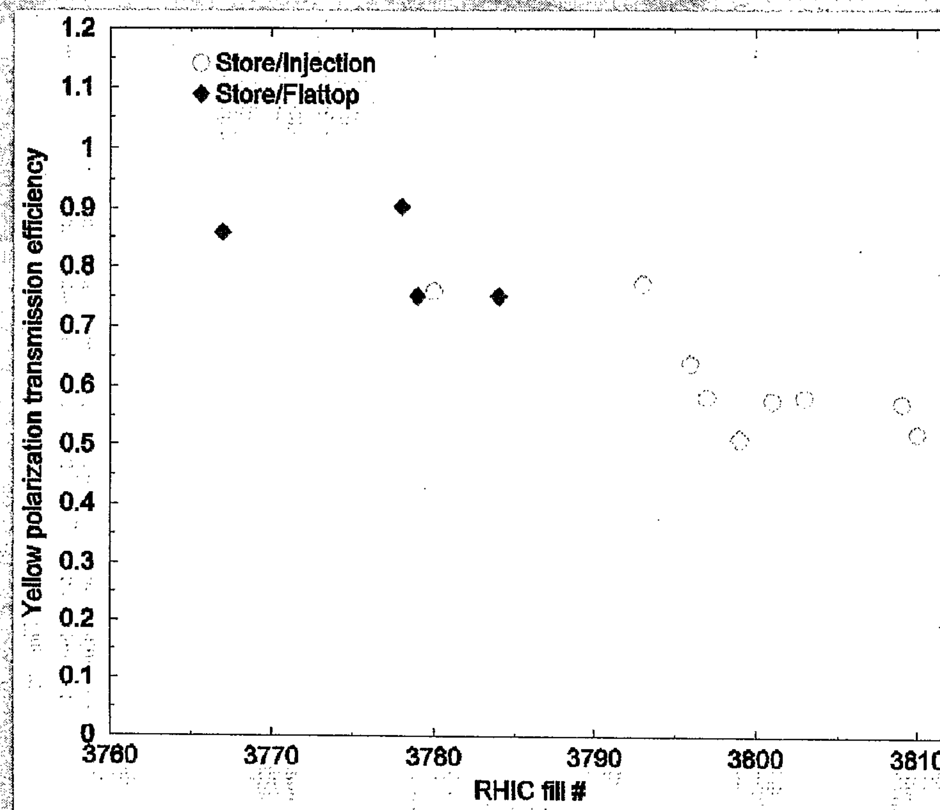




Thanks to Johannes for the helping to extract the polarization data from all the fills.

Polarization efficiency w/o collisions at IP10 and IP2

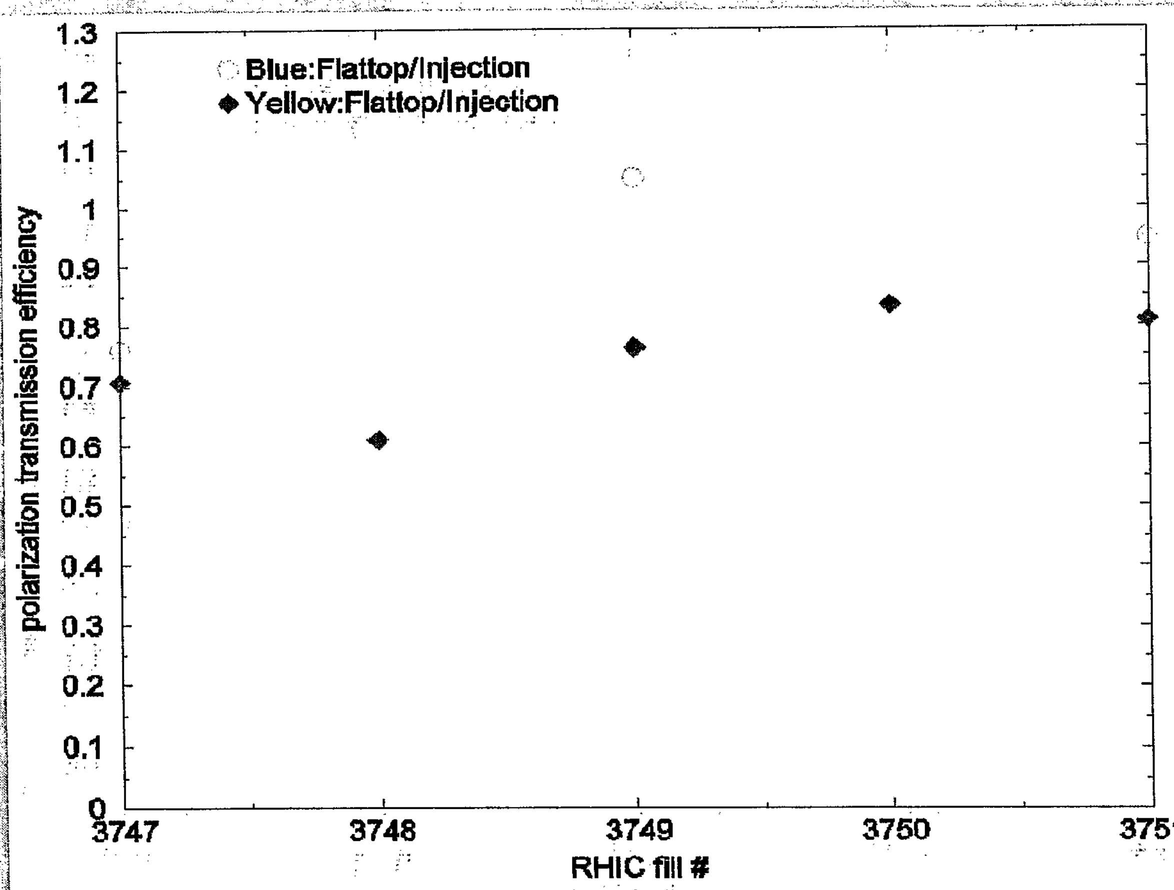




Thanks to Johannes for the help to extract the polarization data from all the fills

Polarization efficiency for pp2pp

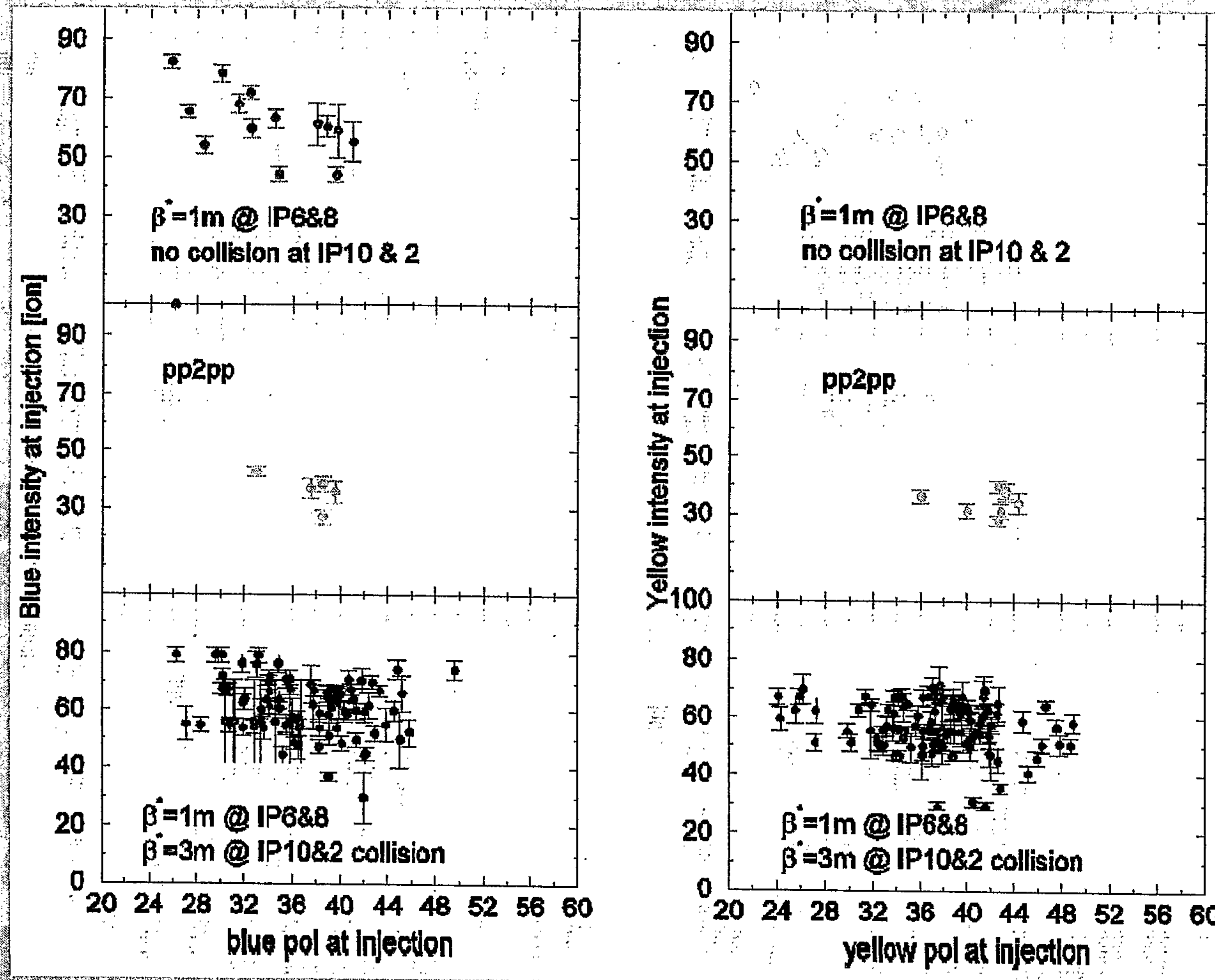
- β* = 10m lattice at injection and store
- lower intensities in both rings



Thanks to Johannes for the help to extract the polarization data from all the fills.

Polarization v.s. Intensity

Blue: lower intensity
high polarization
Yellow: no correlation



no strong correlation
between polarization
and beam intensity

Crucial Beam Parameters for Good Polarization

- Vertical close orbit distortion
  - goal: distortion of the close orbit relative to the golden orbit < 0.5 mm rms
  - golden orbit: flatten orbit
- Betatron tune control
  - 0.214 < (Qx, Qy) < 0.25
  - Qx < Qy
- Beam emittance
- Spin tune
  - Snake current setting

Problems

- Tune spread
  - eliminate the chromaticity wobbles along the ramp
- Linear coupling along the ramp, esp. the beta squeeze part
  - Several schemes are planned for the next run

What can we do during the shutshow?

- Data mining

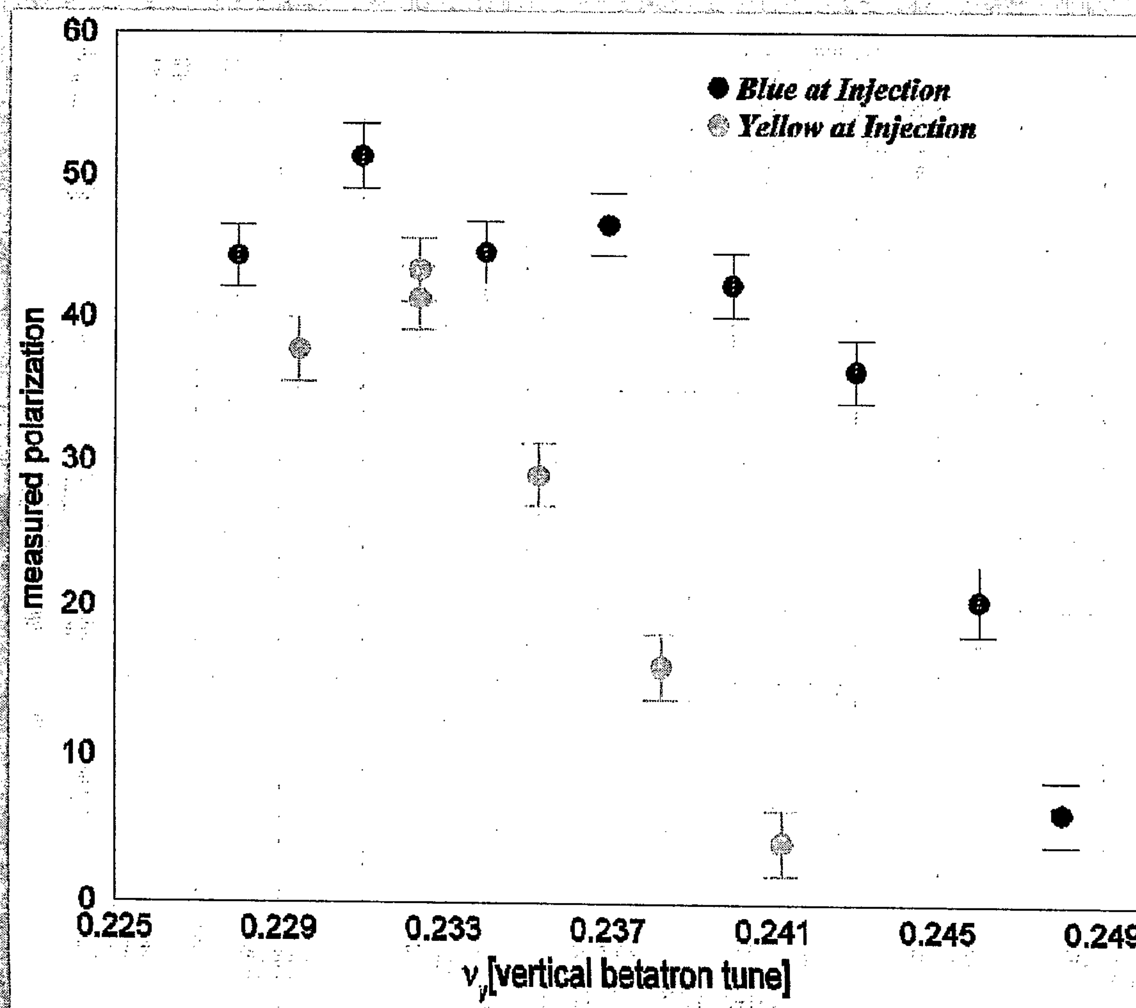
  A database dedicated to this pp run was built by Waldo. We try to load it with all the relevant beam parameters we can possibly get to see whether there is any correlations. Currently we are working on

  - polarization v.s. orbit(……)
  - polarization v.s. betatron tunes as well as the tune spreads

- Simulation, simulation, simulation….

Spin tune at Injection

- blue snake setting
  - bi3-snk7-1.4
    - =bo9-snk7-1.4=100.0A
  - bi3-snk7-2.3=
    - =bo9-snk7-1.4=326.23A
- yellow snake setting
  - yo3-snk7-1.4=100A
  - yi9-snk7-1.4=310.5A
  - yo3-snk7-2.3=326.23A
  - yi9-snk7-2.3=0A
- $0.5-\nu_{sp}$ in blue = 0.496
- $0.5-\nu_{sp}$ in yellow = 0.48

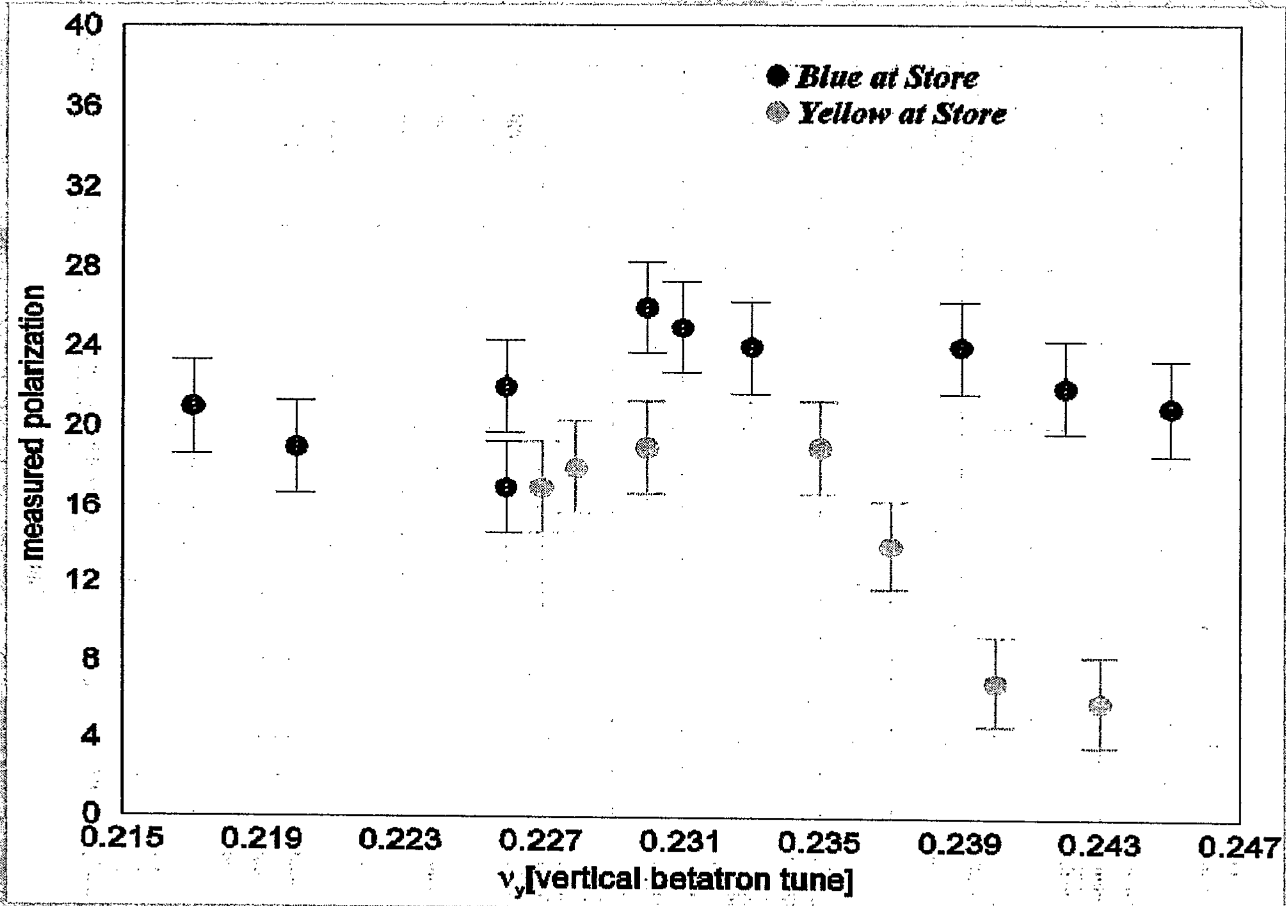


Retune Yellow Partial Snake

- Partial snake current scan
  - keep the vertical betatron tune at 0.24 and measure the beam polarization as a function of the current of snake yi9-snk7-1.4

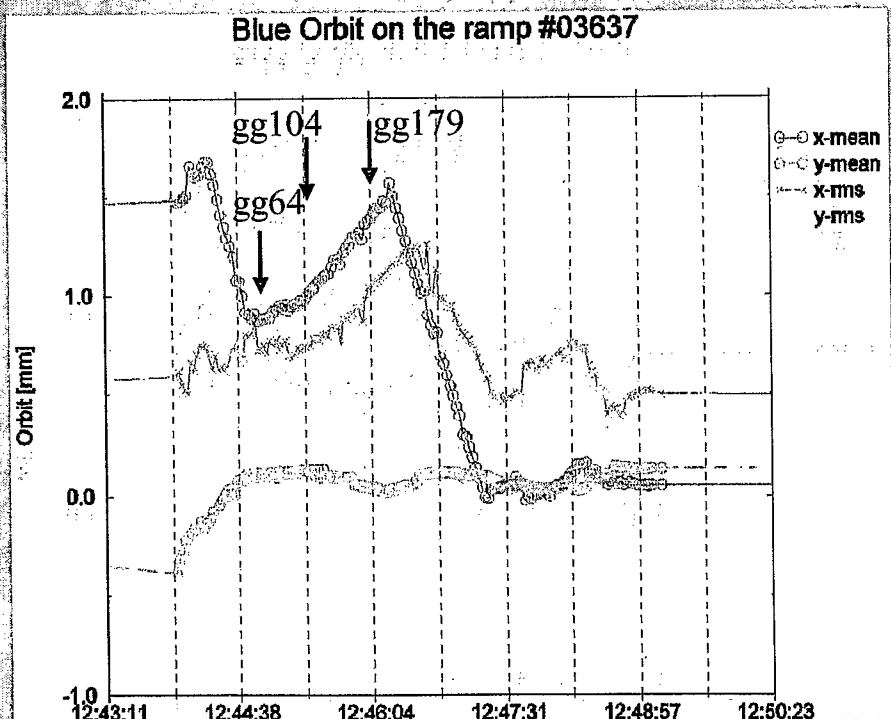
- Spin tune with new snake current
  - snake current 300A gives a spin tune more close to 0.5 than 310A.

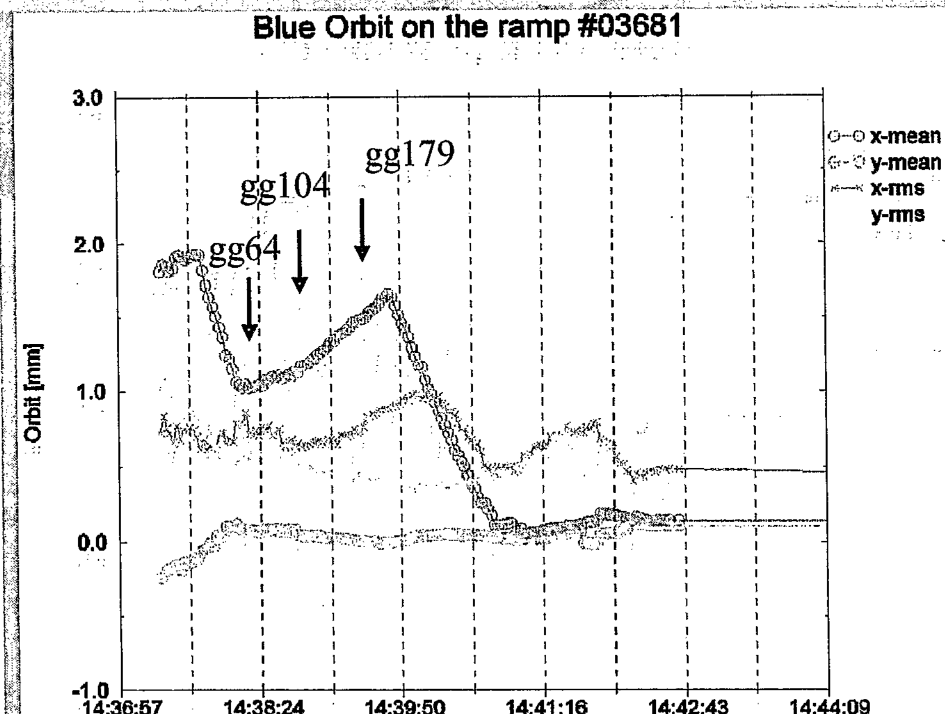
Spin tune at Store



- spin tune in blue at store is very close to 0.5
- spin tune in yellow at store is about 0.01 away from integer

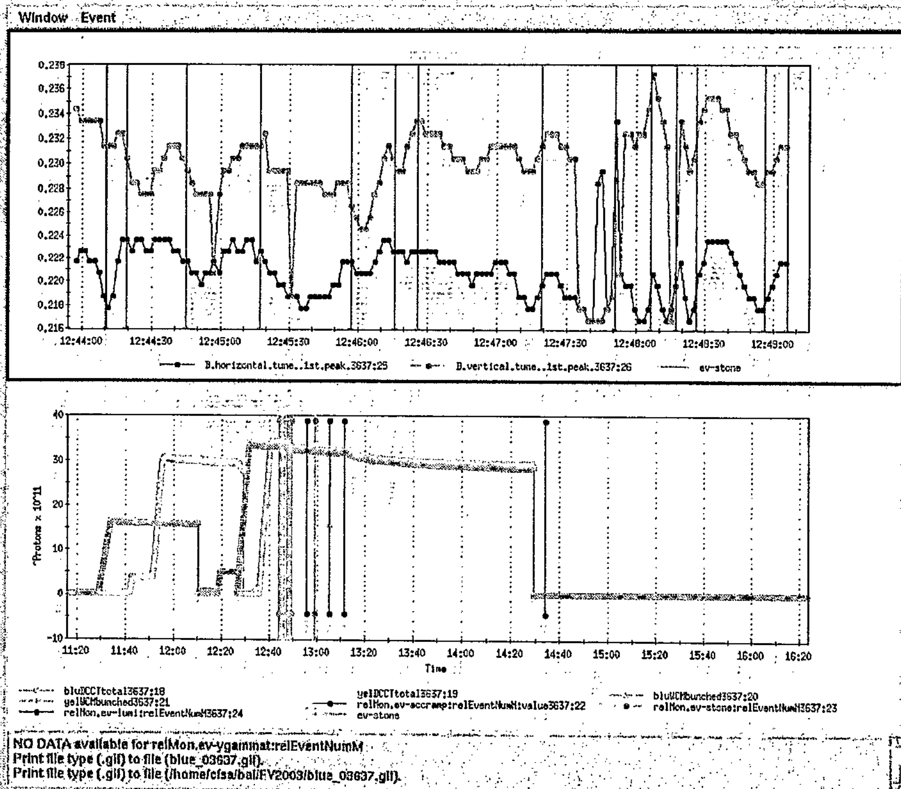
Blue close orbit along the ramp



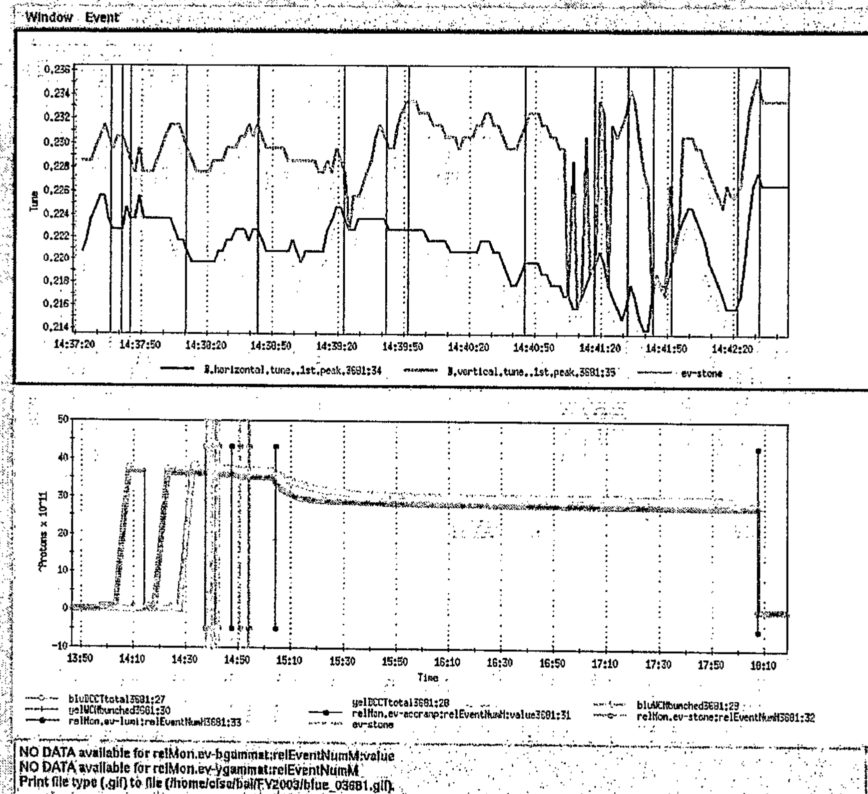


Fill # 3637: Transmission efficiency = 0.80 Fill # 3681: Transmission efficiency = 0.50

Blue tunes along the ramp



Fill # 3637. Transmission efficiency = 0.89



Fill # 3681. Transmission efficiency = 0.50

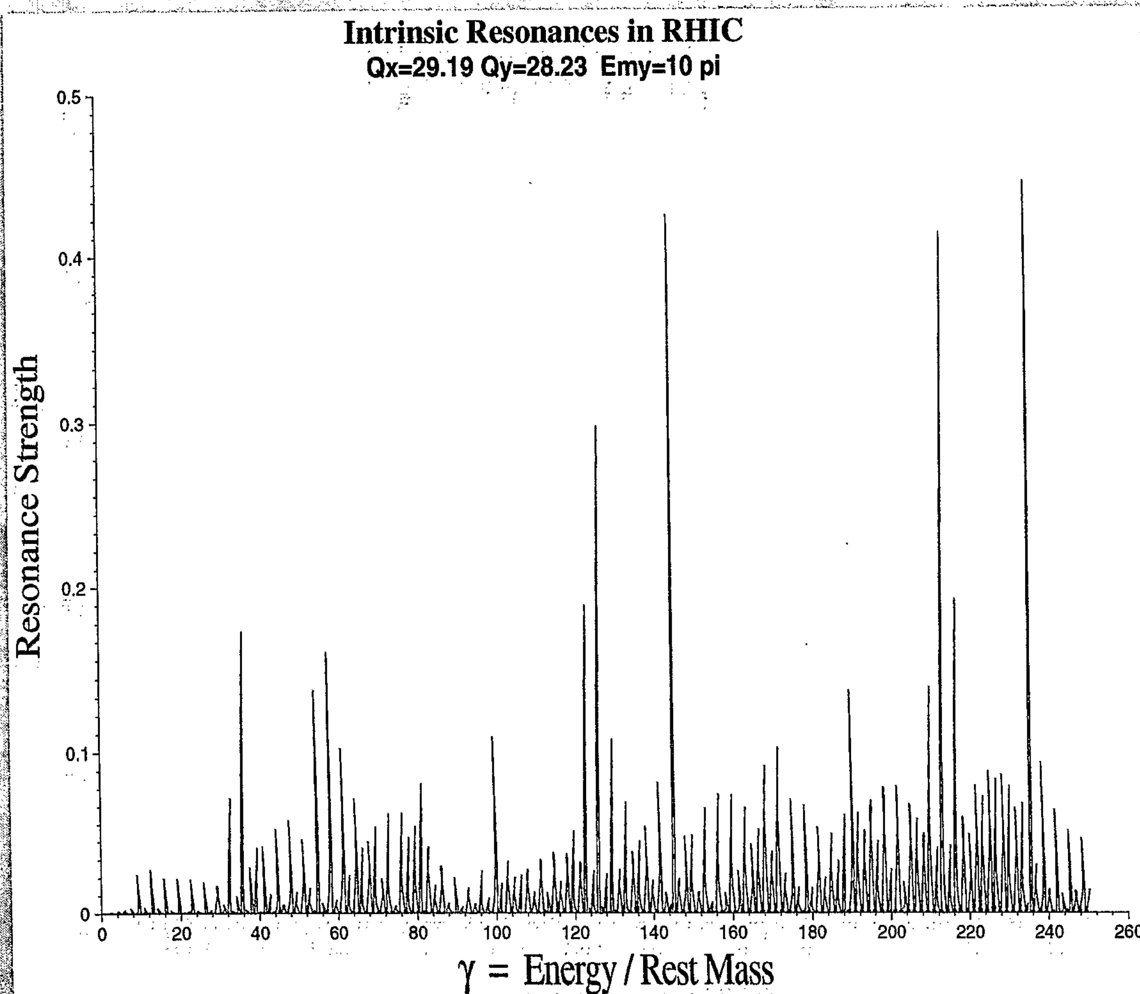
RHIC Intrinsic Resonance Spectrum

- 3 major intrinsic spin resonances between $G\gamma=46.5$ and $G\gamma=191$ they are

  $G\gamma = 64$

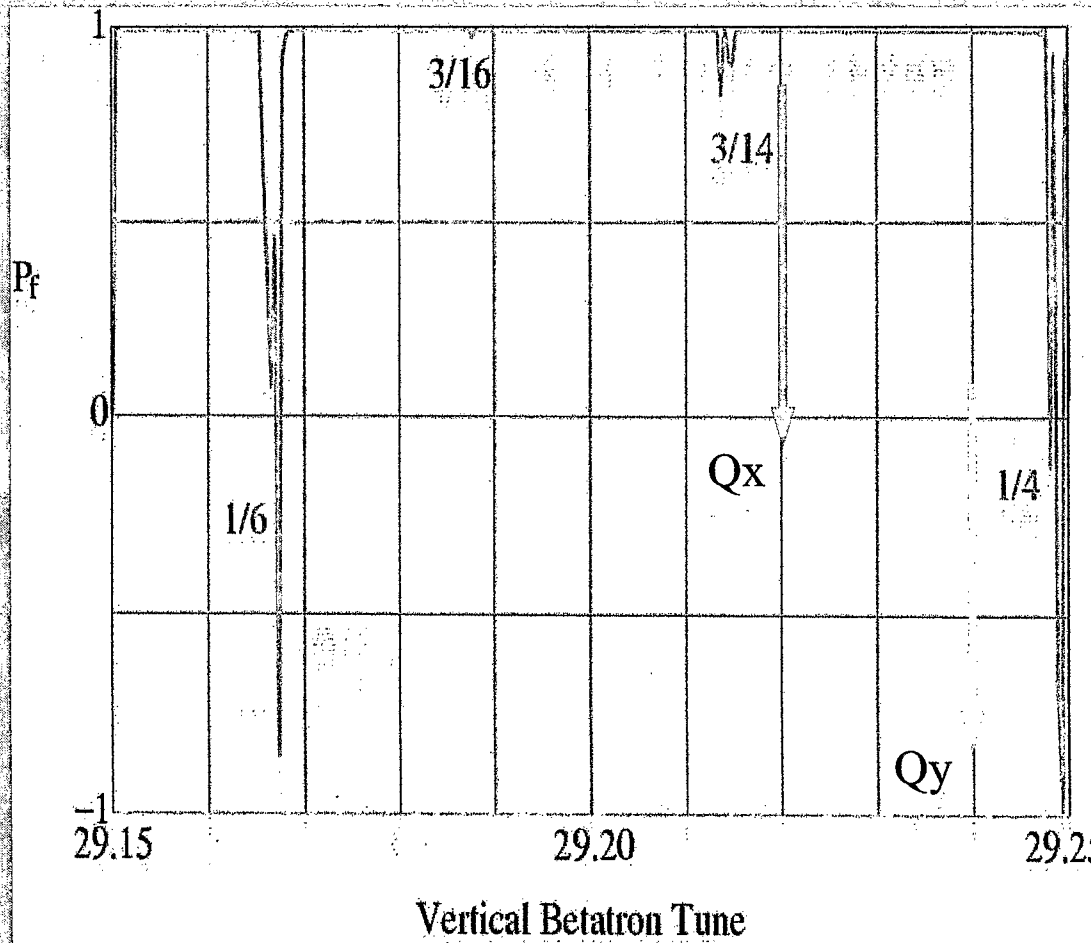
  $G\gamma = 104$

  $G\gamma = 179$

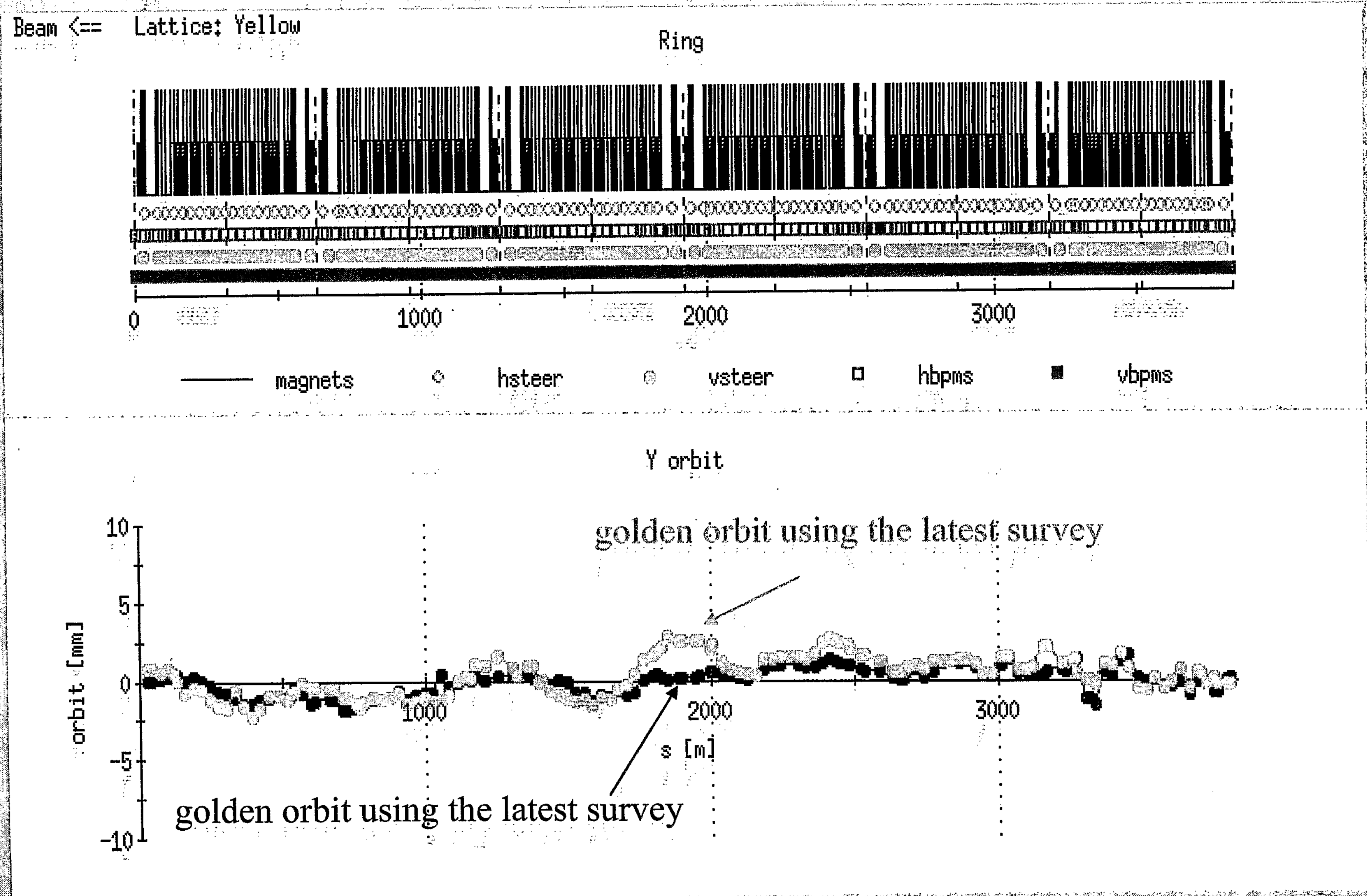


RHIC Snake Resonance Spectrum

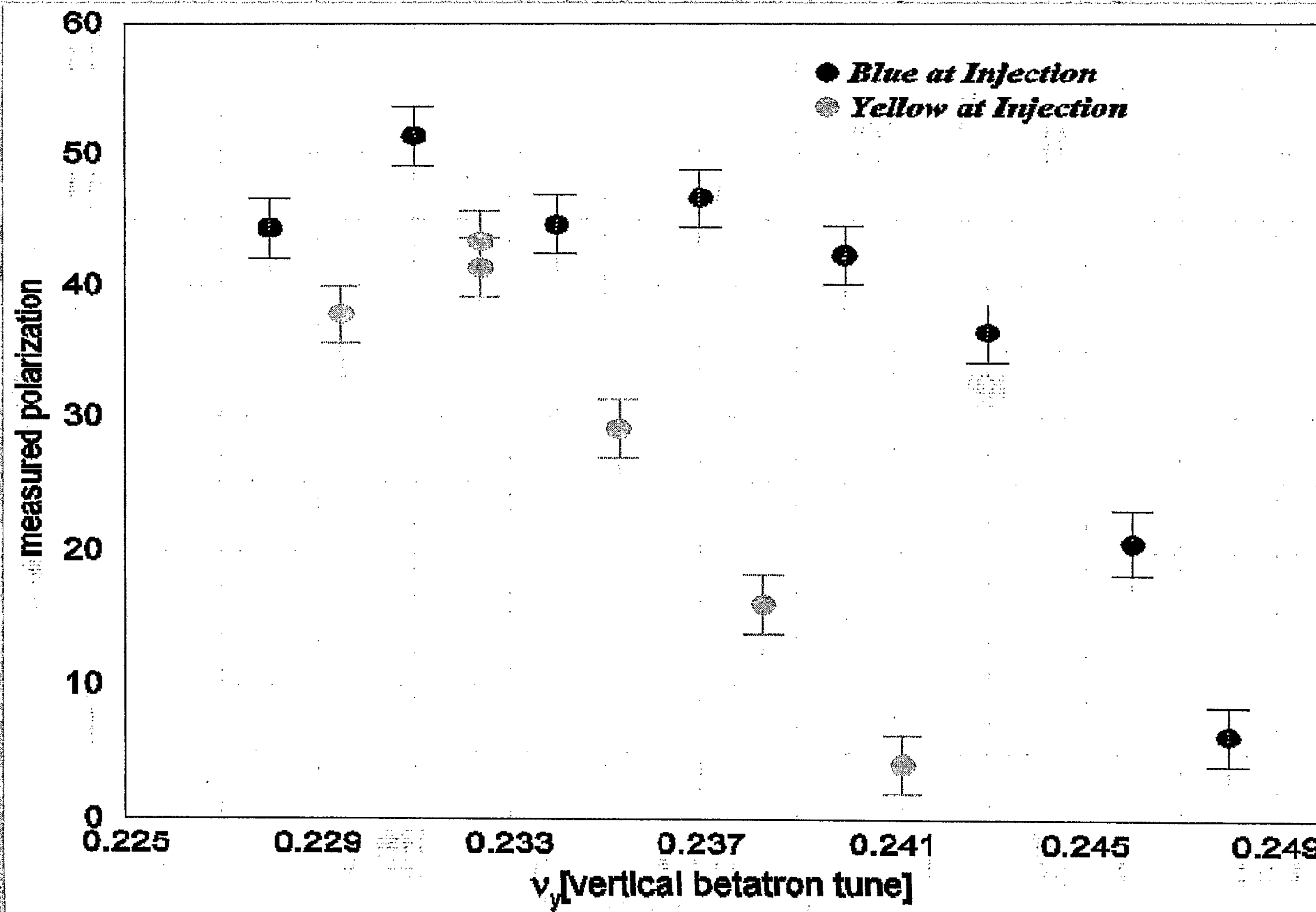
- each resonance is propotional to the imperfection spin resonance
- even order snake resonance is more sensitive to the imperfection resonance



RHIC golden orbit

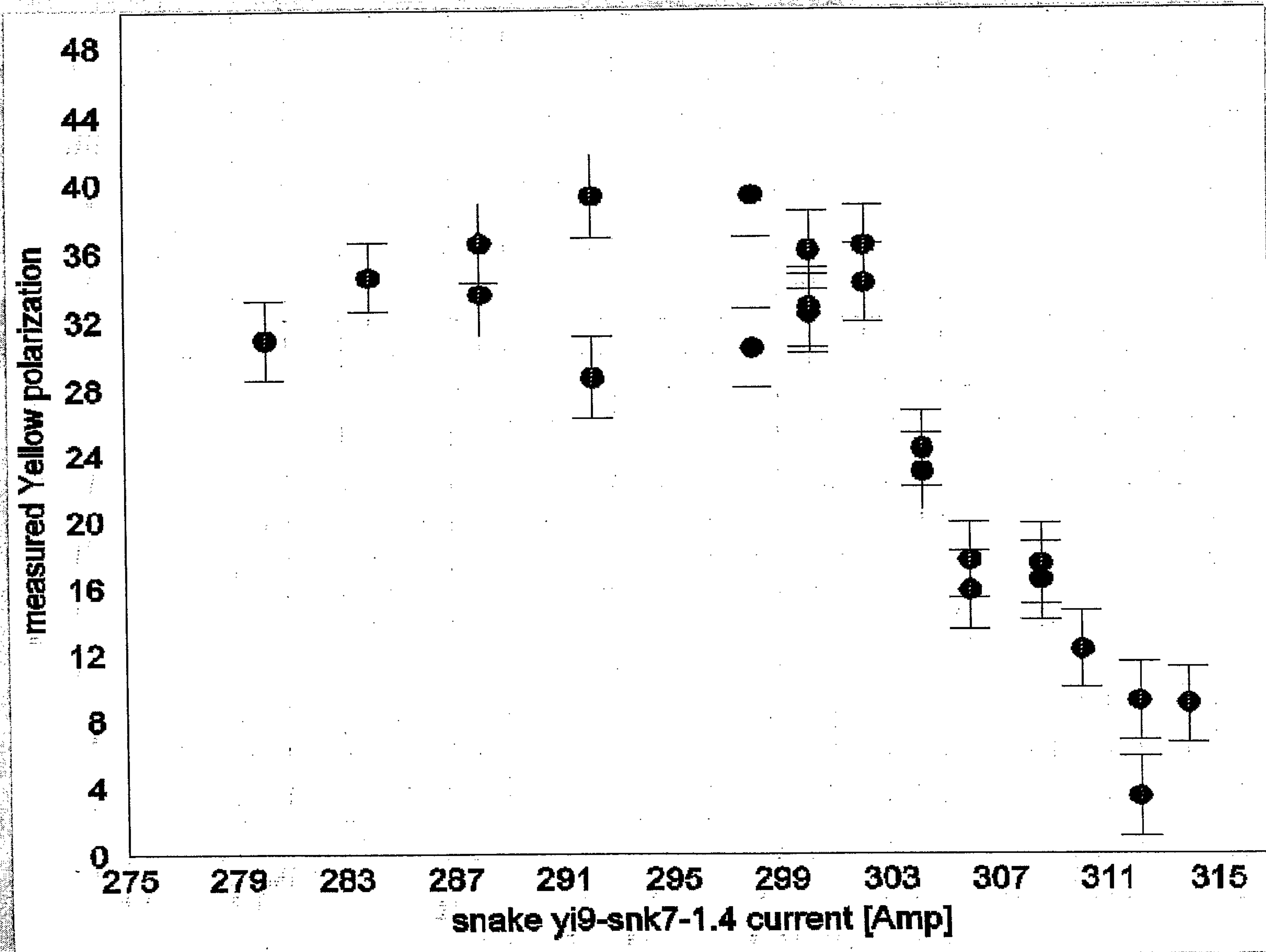


Tune Scan (1)

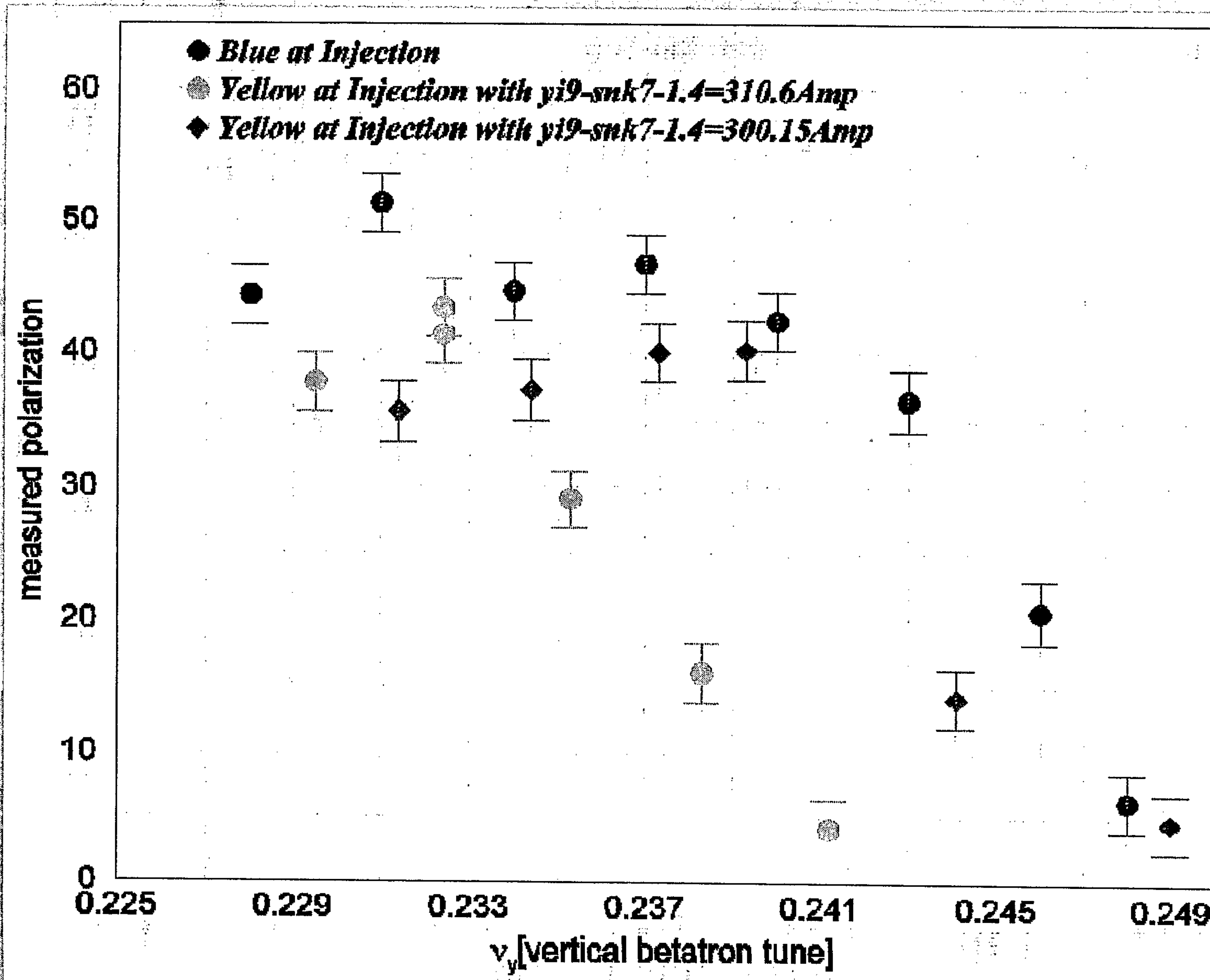


Blue at Injection
Yellow at Injection
measured polarization
0
10
20
30
40
50
60
0.225
0.229
0.233
0.237
0.241
0.245
0.249
ν_y[vertical betatron tune]

Yellow partial snake current scan



Tune scan (2)



Blue at Injection
Yellow at Injection with yi9-snk7-1.4=310.6Amp
Yellow at Injection with yi9-snk7-1.4=300.15Amp
measured polarization
0
10
20
30
40
50
60
0.225
0.229
0.233
0.237
0.241
0.245
0.249
ν_y[vertical betatron tune]

Polarized Proton Collisions at 500 GeV

RHIC resonance strengths

Spin tracking

Performance requirements

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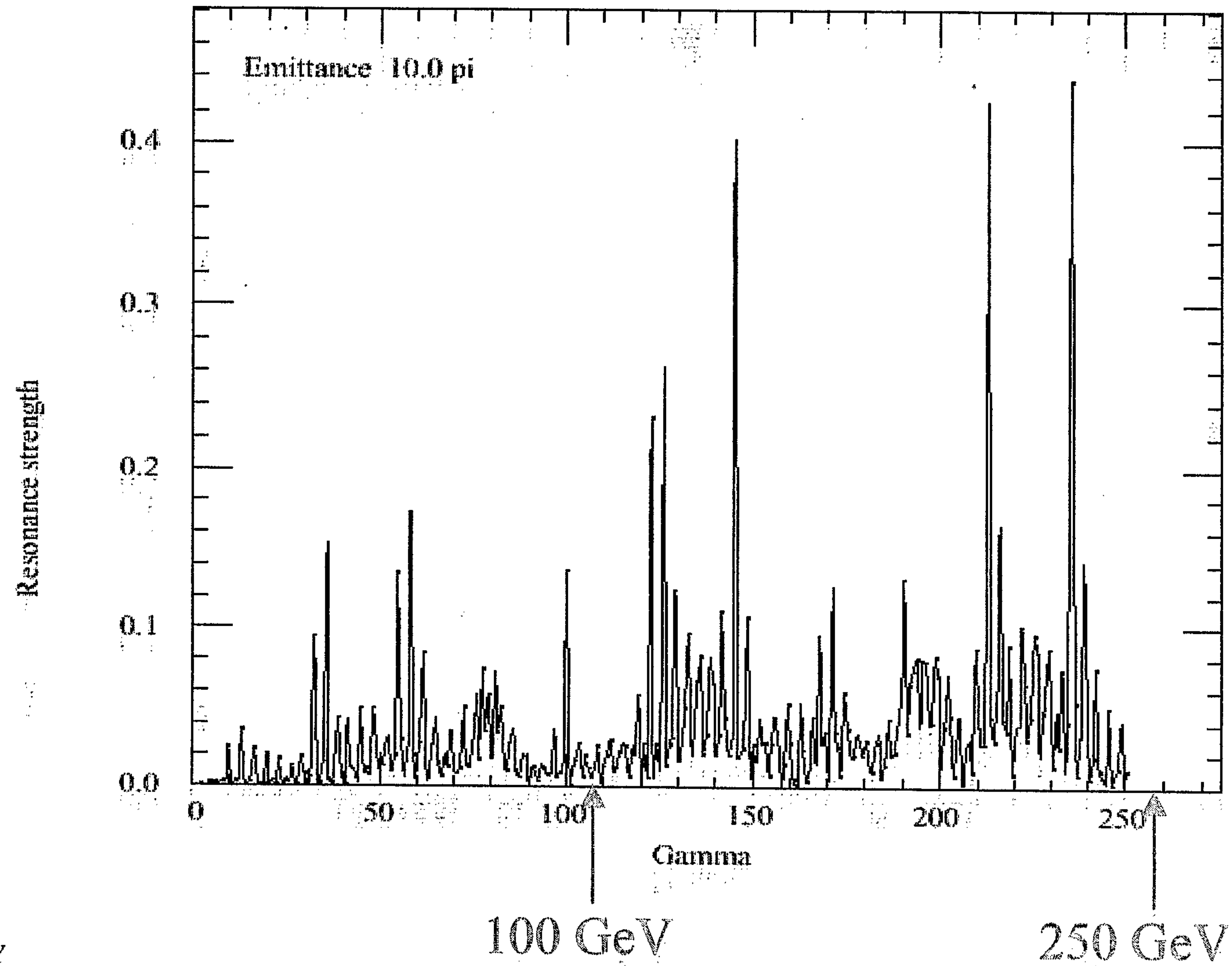
Thomas Roser
RSC
June 20, 2003

RHIC intrinsic resonances



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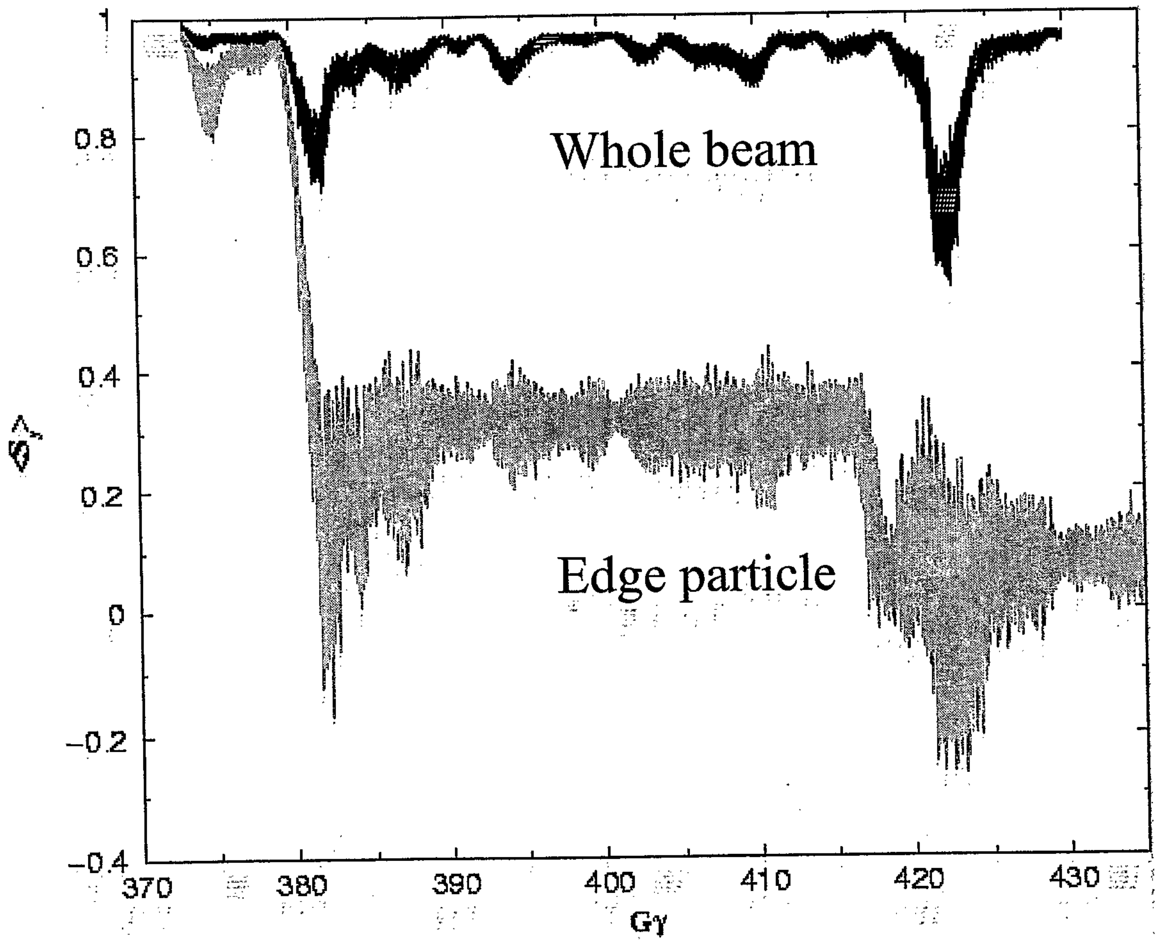
Spintracking trough strongest RHIC resonance



- Two Siberian snakes
- 1 mm rms misalignment (Survey: < 0.5 mm)
- 0.2 mm rms closed orbit
- 20 π μm emittance (95%)

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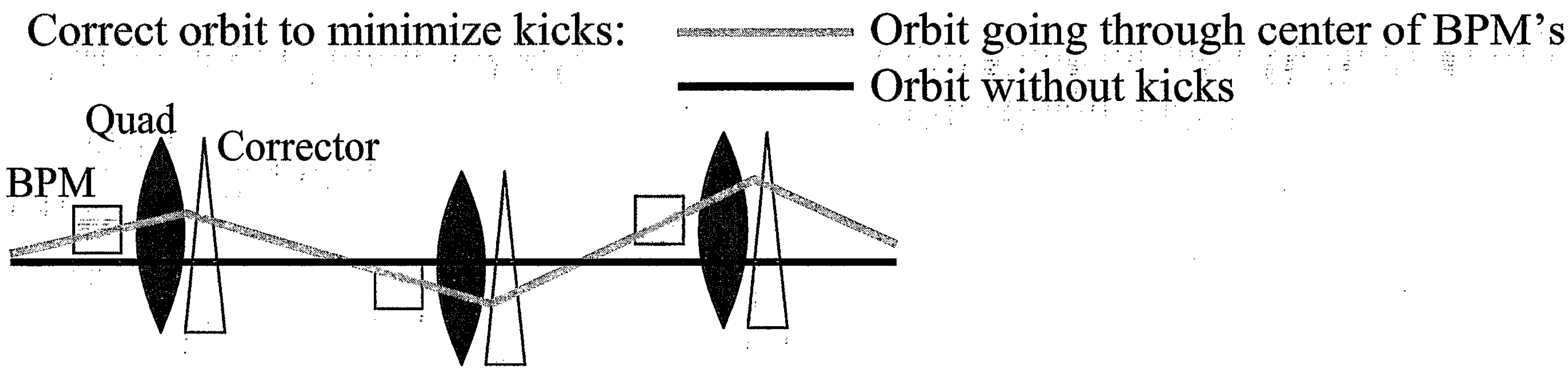
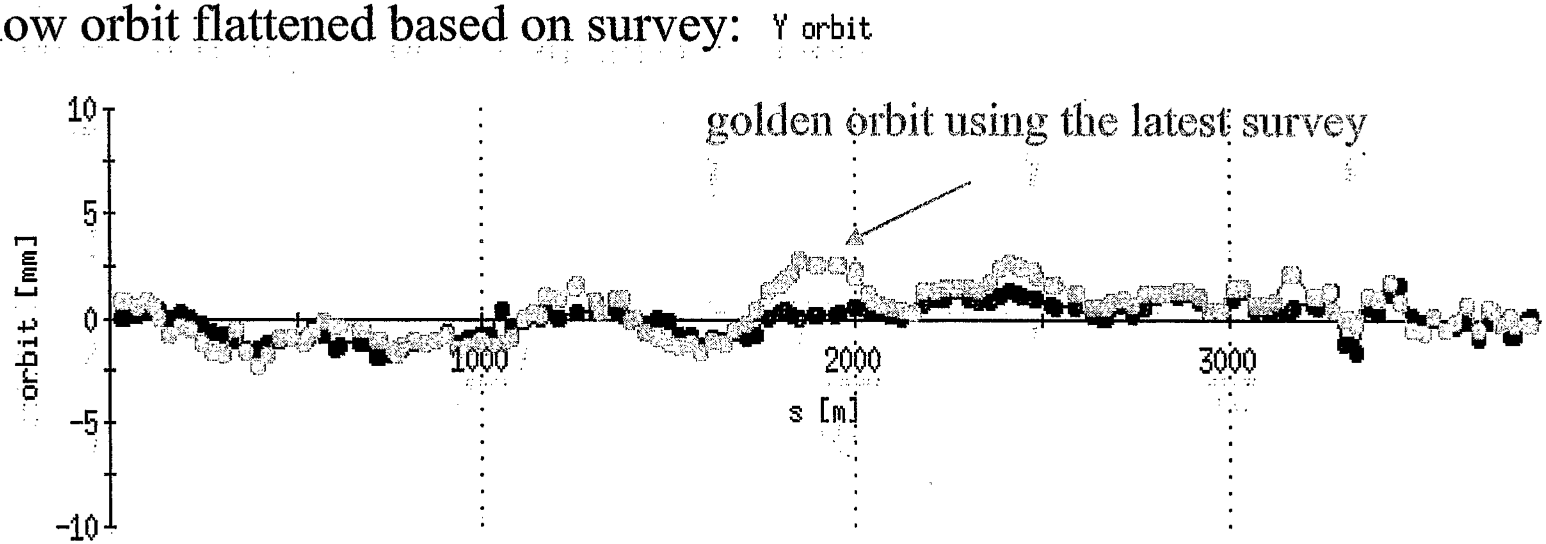
Ideal Orbit for Polarization

Correct orbit to minimize kicks: Orbit going through center of BPM's; Orbit without kicks



Yellow orbit flattened based on survey:



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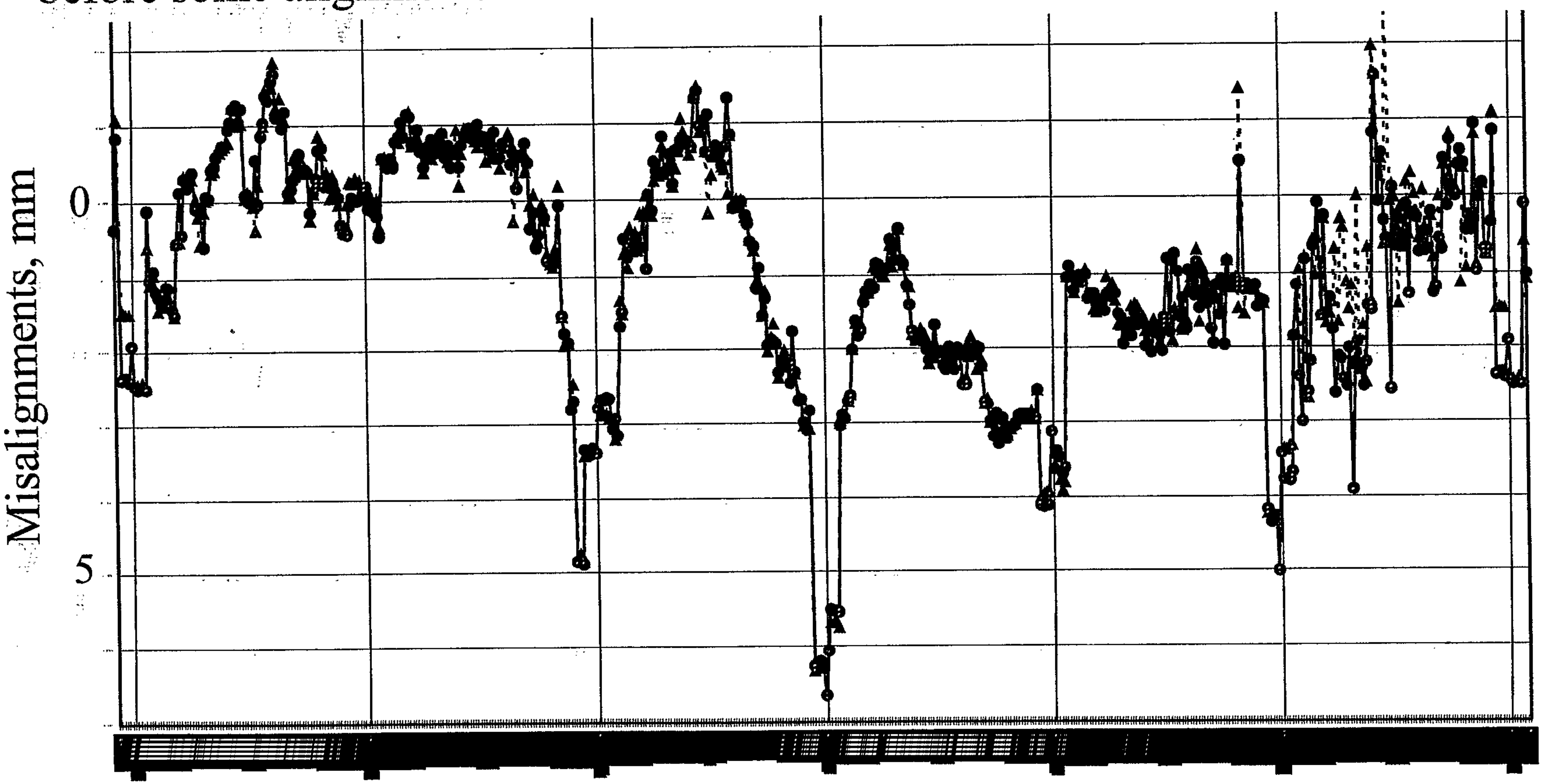
RHIC misalignments (2002 data)

Average of cold mass fiducials derived from tunnel monument misalignments before some alignment:



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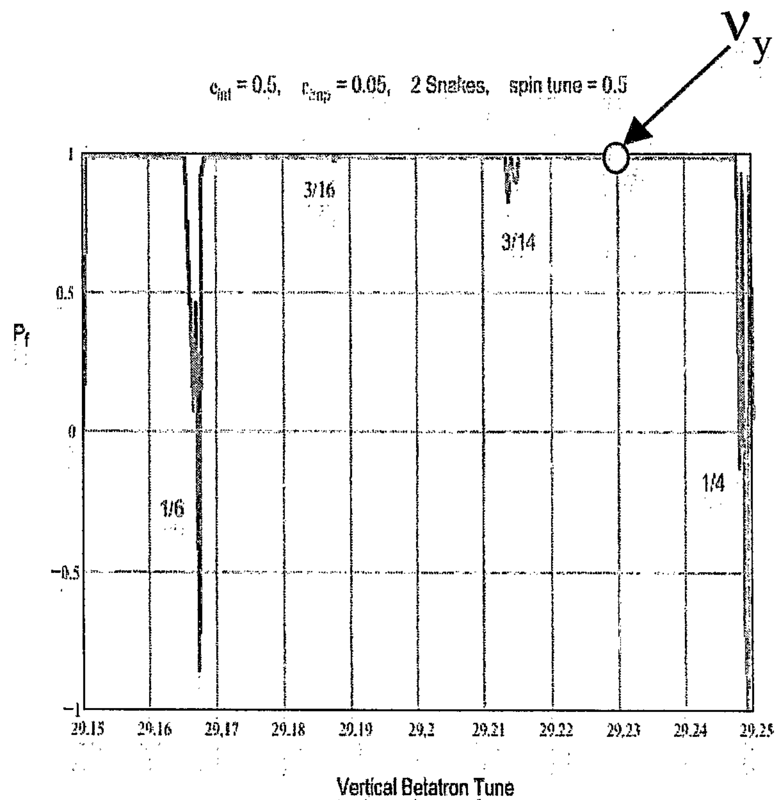
RHIC Polarization Set-up

2 Siberian Snakes per ring hold the spin tune ½ all the way up during the acceleration

The vertical tune was chosen at 0.23, between 2 high-order spin resonances:

- 1/4=0.25 ; depends on vertical orbit
- 3/14=0.2143; exists even without orbit errors

Is there a better working point ?



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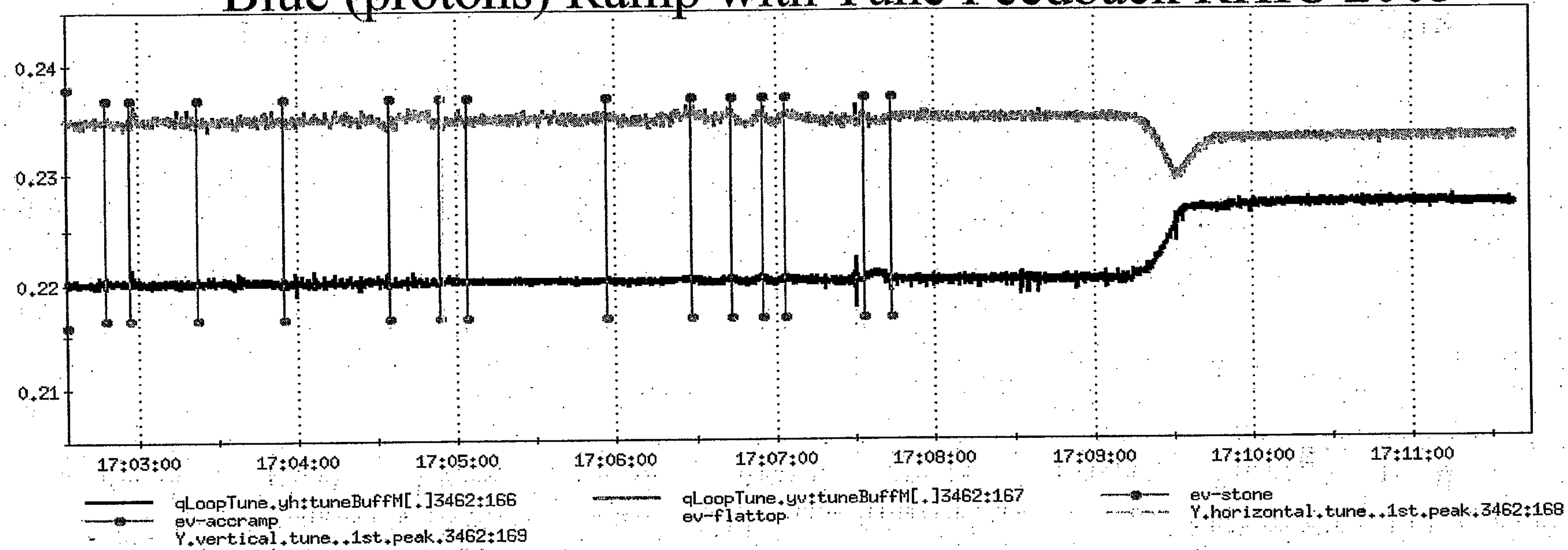
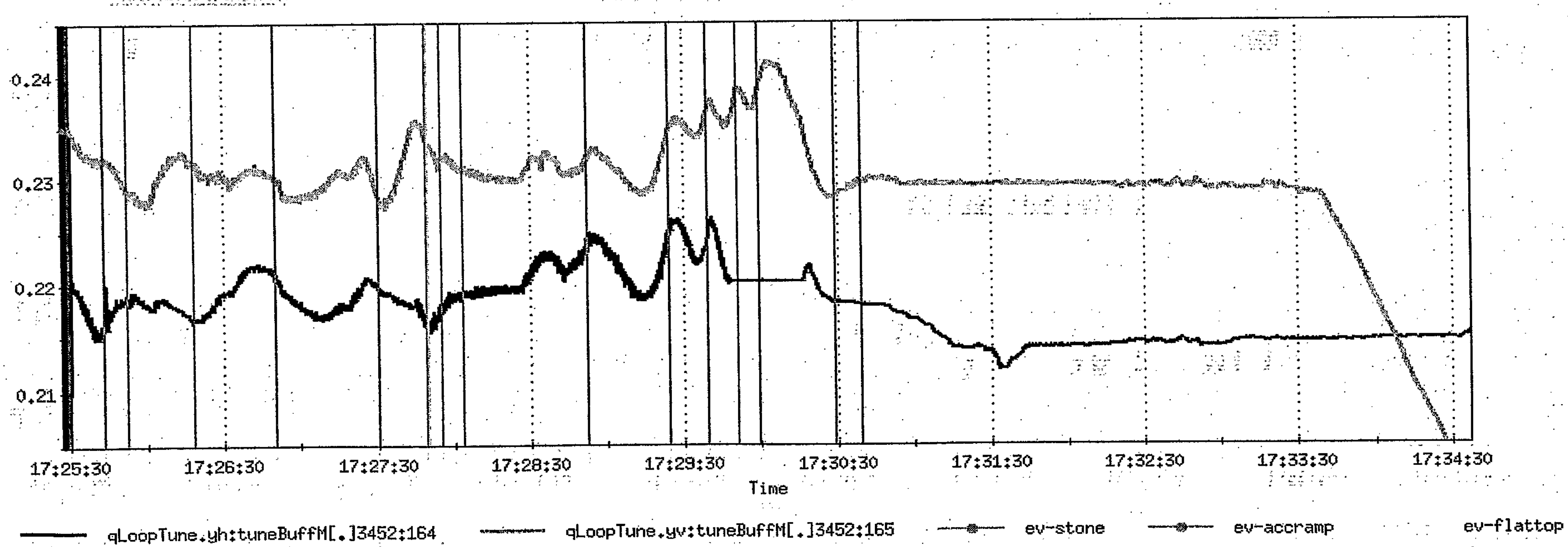
Fri Apr 11 13:19:26 - Sun Apr 13 23:36:43

Window Event

Blue (protons) Ramp with Tune Feedback RHIC 2003





Requirements for polarized proton acceleration to 250 GeV

Two full Snakes adjusted to spin tune of 0.50 in both rings

New tune working point ?

Closed orbit correction to better than 0.5 mm rms

- Good survey/alignment and "ideal orbit"
- Orbit correction feed-forward
- Beam based orbit flattening by minimizing vertical dispersion (?)

Betatron tune control to better than 0.005 (DQ/Q ~ 0.0001)

- Active PPL tune feed-back system

Low emittance beams during acceleration (blow-up before collisions?)

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RHIC Run 4 Running Projections (FY2004)

Thomas Roser, Wolfram Fischer

June 20, 2003

This note discusses possible operating modes for the RHIC FY2004 running period including constraints from cryogenic cool-down, machine set-up and beam commissioning.

Cryogenic operation – After the summer shutdown the two RHIC rings will be at room temperature. They will be first brought to liquid nitrogen temperature, in about 10 days. Then, two weeks will be required to cool down to 4 Kelvin. At the end of the run, one week of refrigerator operation is required for the warm-up to 80 Kelvin.

Running modes – A number of running modes are considered in RHIC, such as Au-Au collisions, polarized proton collision, and Si-Si collisions. For each mode we should plan for 2 weeks of machine set-up with the goal of establishing collisions, and a 3-week machine development period ("ramp-up") after which stable operation can be provided with integrated luminosities that are a fraction of the maximum goals shown below. During the ramp-up period detector set-up can occur, however with priority for machine development.
Higher weekly luminosities can be achieved with a continuous development effort in the following weeks. At this year's RHIC retreat is was proposed to use the day shifts from Monday to Friday for this effort, with enough personnel available in the following shift to ensure production during the evening and night shift. The luminosity development efforts should stop when insurmountable limits, posed by the current machine configuration, are reached. After a running mode has been established, a change in the collision energy can be achieved in about 2 weeks (1 week set-up and 1 week ramp-up).

For example, the expected 27 weeks of RHIC refrigerator operation during FY2004 could be scheduled in the following way for two RHIC operating modes:

Cool-down from 80K to 4K	2 weeks
Set-up mode 1	2 weeks
Ramp-up mode 1	3 weeks
Data taking mode with further ramp-up 1	7 weeks
Set-up mode 2	2 weeks
Ramp-up mode 2	3 weeks
Data taking mode with further ramp-up 2	7 weeks
Warm-up	1 week

Since the highest weekly luminosities are reached at the end of each mode, the integrated luminosities are maximized with long runs in each mode, and as few mode changes as possible.

Past performance – Table 1 shows the Au-Au luminosities achieved at the end of the Run 2 (FY2001/02), and the p-p luminosities achieved in Run 3 (FY2003). The quoted average store luminosity was for a store with no hardware problems and with a luminosity that agreed well with predicted values from intensity and beam emittance (store # 1812 for Au-Au, store # 3810 for p-p). The integrated weekly luminosity is the average over the last few weeks during which the luminosity was fairly constant. The ratio of average weekly luminosity over store luminosity was 27% and 17% for Au-Au and p-p, respectively. Note that this includes all interruptions such as maintenance, studies, etc.

Mode	# bunches	Ions/bunch [$\times 10^9$]	β^* [m]	Emittance [μm]	L_{peak} [$cm^{-2}s^{-1}$]	L_{ave}(store) [$cm^{-2}s^{-1}$]	L_{ave} (week) [$week^{-1}$]
Au-Au	55	0.6	1	15-40	3.7×10^{26}	1.5×10^{26}	24 $(\mu b)^{-1}$
($p\uparrow$-$p\uparrow$)	55	70	1	20	6.0×10^{30}	3.0×10^{30}	0.3 $(pb)^{-1}$

Table 1: Achieved beam parameters and luminosities for Au-Au (Run 2) and p-p (Run 3).

Luminosity projections – Table 2 lists the expected maximum peak and average luminosities for the possible modes in FY2004 that could be achieved after a sufficiently long running period, typically many weeks, unless thus far unknown machine limitations are encountered. With experience from past runs we expect luminosities at the end of the 3-week ramp-up period to be lower by about an order of magnitude. For all modes it was assumed that the beam energy is 100 GeV/nucleon. The average store luminosity is for a "good" store as defined above. This is a number predictable from the beam parameters. The weekly integrated luminosity was then obtained by using a ratio of 40% between average weekly and average store luminosity, based on our experience from d-Au running. The expected diamond rms length is 20 cm due to the availability of the full voltage from the 200 MHz storage cavities.
Note that the quoted luminosities are for $\beta^* = 1$ m. This is only available at PHENIX and STAR. PHOBOS and BRAHMS are limited to $\beta^* \geq 3$m due to the lack of nonlinear IR correctors. β^* at PHOBOS is further limited by the beam abort system in IR10, and may need to be larger than 3m. For pp running these luminosities can only be provided at two IRs simultaneously due to limitation from beam-beam effects. Due to the required abort gaps in both beams, collisions of 56 bunches can only be provided for two opposing IPs. The other IPs will have a 10% reduction in the number of collisions.

Mode	# bunches	Ions/bunch [$\times 10^9$]	β^* [m]	Emittance [πμm]	L_{peak} [$cm^{-2}s^{-1}$]	L_{ave}(store) [$cm^{-2}s^{-1}$]	L_{ave} (week) [$week^{-1}$]
Au-Au	56	1	1	15-40	14×10^{26}	3×10^{26}	70 $(\mu b)^{-1}$
($p\uparrow$-$p\uparrow$)	56	100	1	20	8×10^{30}	5×10^{30}	1.8 $(pb)^{-1}$
Si-Si	56	7	1	20	5×10^{28}	2×10^{28}	5 $(nb)^{-1}$

Table 2: Maximum luminosities that can be reached after a sufficiently long running period.

Time dependence of integrated luminosity – Since we expect many weeks of continuous ramp-up to reach the maximum weekly luminosities, the total integrated luminosities will be strongly time dependent. This is illustrated in Figure 1, which shows as a function of time the integrated Au-Au luminosity achieved in Run 1 as well as Au-Au projections for Run 4. For the projected minimum it is assumed that the demonstrated weekly luminosity, given in Table 1, is reached after 14 weeks of linear ramp-up. For the projected maximum it is assumed that the weekly Au-Au luminosity in Table 2 is reached after 14 weeks of linear ramp-up.

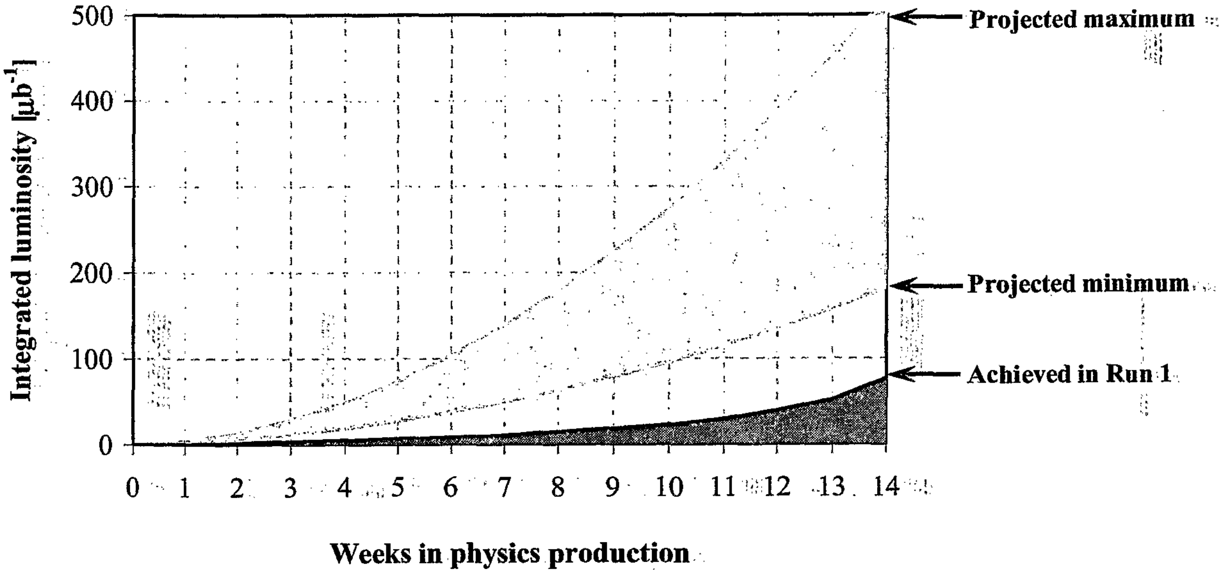

Figure 1: Integrated Au-Au luminosity achieved in Run 1, and projected minimum and maximum integrated luminosities for Au-Au collisions assuming linear weekly luminosity ramp-up in 14 weeks.

Impact of mode switching – Table 3 shows the impact of mode switching on the integrated luminosity. Compared are the total integrated luminosities per mode for a run with 1 mode (19 weeks of data taking) and 2 modes (7 weeks/mode of data taking). In both cases it is assumed that the weekly luminosity can be increased linearly in time, and that the minimum or maximum weekly luminosities are reached after 14 weeks of data taking.

Mode	Integrated luminosity per mode			
	1 Mode (19 weeks)		2 Modes (7 weeks/mode)	
	Minimum	Maximum	Minimum	Maximum
Au-Au	290 (μb)$^{-1}$	840 (μb)$^{-1}$	42 (μb)$^{-1}$	122 (μb)$^{-1}$
(p↑-p↑)	5.0 (pb)$^{-1}$	23.0 (pb)$^{-1}$	1.6 (pb)$^{-1}$	4.2 (pb)$^{-1}$
Si-Si	?	60 (nb)$^{-1}$	?	9 (nb)$^{-1}$

Table 3: Projected total integrated luminosities per mode for 1 and 2 modes, assuming linear weekly luminosity ramp-up in 14 weeks.

Following are specific comments on the running modes:

Gold on gold – The installation of NEG coated beam pipes is expected to raise the threshold amount of beam that can be accelerated and stored. NEG coated beam pipes near Phobos should also reduce the background at this experiment. A reduction of the experimental background is also expected from a major upgrade in the collimation system, as well as the installation of shielding. Efforts are under way to eliminate the machine maintenance time due to ice formation at power leads, and to improve the reliability of corrector power supplies. A number of software projects will increase the operational efficiency. An extra rf bunch merge in the Booster should lead to a more reliable delivery of high-intensity Au bunches into RHIC.

Polarized protons on polarized protons – We are proposing that a possible RHIC p-p run is scheduled later during the RHIC run so that a 4 week AGS polarized proton commissioning run can be completed before a RHIC p-p run would start. A p-p run could be used to test new equipment and demonstrate acceleration to 250 GeV, which would be very important to prepare for future polarized proton running. A normal conducting helical partial snake, to be installed in the AGS, should increase the polarization at AGS extraction from 40% to 50%. In RHIC, a polarized gas jet target can be commissioned. For this an access period of a few days for installation is needed before a p-p run.

Silicon on silicon – The listing for Si-Si serves as an example of an intermediate heavy ion. Si is easily produced by the injector and with an equal number of protons and neutrons acceleration in RHIC is the same as for deuterons.

RHIC Spin Collaboration Meeting XVII

June 20, 2003

RIKEN BNL Research Center

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RHIC Spin Collaboration Meeting XVII

June 20, 2003

Small Seminar Room, Physics Dept., Brookhaven National Laboratory

*******AGENDA*******

Morning Session

09:00 – 09:45	Status of the Jet Target	Y. Makdisi
09:45 – 10:20	Status of the Jet Target Experiment	S. Bravar
10:20 – 10:30	Coffee Break	
10:30 – 10:50	Thoughts on Polarized p+p in Run-4 and Beyond from STAR	L. Bland
10:50 – 11:10	Thoughts on Polarized p+p in Run-4 and Beyond from PHENIX	Y. Goto
11:10 – 11:30	Thoughts on Polarized p+p in Run-4 and Beyond from BRAHMS	B. Fox
11:30 – 11:50	Thoughts on Polarized p+p in Run-4 and Beyond from pp2pp	S. Bueltmann

Afternoon Session

2:00 – 2:40	AGS: Lessons from Run-3, What is in the works for Run-04?	L. Ahrens
2:40 – 3:30	RHIC: Lessons from Run-3	H. Huang
	RHIC: Lessons from Run-3	M. Bai
3:30 – 3:40	Coffee Break	
3:40 – 4:00	500 GeV: What does it take?	T. Roser
4:00 – 5:00	Discussion, Run-4 and Beyond	

Summary of RHIC Spin Collaboration Meeting June 30, 2003
by Brendan Fox

(1) Did we reach saturation of luminosity and polarization during the pp running in Run-03 where saturation is being defined relative to what could be achieved with current understanding and hardware?

- Luminosity

No, the bunch currents were 0.7e11; we could probably have reached 1.0e11 which, for 50 bunches, reaches the 1e13 limit on total current (sum of both rings) which arises from the vacuum pressure rise and subsequent severe background issues at the experiments. Two more weeks of running without any concerns of polarization would have been helpful on this matter.

- Polarization

Yes.

(2) What are critical machine issues for Au-Au?

- bunch merging in the booster to bring up the Au intensity to 1e9

* this involves stacking bunches in the booster and requires improvements to the rF system. These improvements are underway during the current shutdown.

* by stacking bunches, we draw more ions from the tandem and there is a worry about the foils in the source. This is likely not an issue for Run-4 since you have two tandems, so, if one goes out, you can use the other while working on the down one.

* since the bunches will be stacked longitudinally, it is important to control the longitudinal emittance; otherwise, one cannot stack as many "initial" bunches into a single "final" bunch. This matter needs to be studied.

- storage rF

* this was improved during the dA run by eliminating some noise in the system.

* during the dA running, the three common mode cavities was not used since the two species do not have the same requirements. So, these cavities will provide additional power per beam in Run-04. However, the tuning of the common mode cavities is trickier because both beams are affected by the same cavities.

* during Run-3, especially near the end of the pp run, the storage rF tripped off often. These trips were likely a result of having lost one of the windows in the rF system. All of the other windows survived so it is likely that this window was just the weakling. So, this should not be as much of problem in Run-04.

* in the past, the storage rF cavities have also served as Landau cavities during the ramp. This year, dedicated Landau cavities are being installed.

* as a goal, they aim to squeeze the longitudinal profiles so that 60 and 65% of the collision vertices are usable at PHENIX.

- stochastic cooling

* this idea addresses issues of growth of the bunch during a store.

* there is a plan to install a kicker & pickup at 12:00 and 4:00 during this shutdown so that the use of schochastic cooling can be studied during Run-04.

- the NEG coating and addressing the pressure rise problem

* focusing on the areas most affected by the pressure rise problem, the plan is to coat 60m of approximately 700m of warm section in RHIC with a NEG coating during this summer. This coating will serve as a getter which will sucks up residual gas and holds it better.

* some possible side effects: coating could affect the impedance of the machine, might affect the pumping (though that should be a positive not negative effect), and one needs to think about how the hydrogen jet target and the coating co-exist.

- beam lifetime

Unlike in p-p, Au-Au is not as affected by the beam-beam interaction because its Z/A is 0.4 that of p. The issue for Au+Au is more one of intrabeam interaction. From simultuations, the lifetime is expected to be ~1.5 hours for Au-Au with 1e9 ions per bunch.

(3) What are critical machine issues for p-p?

- polarization from the AGS

* for Run-4, the warm helical snake will be in place. With this, they expect to raise the AGS polarization from ~0.4 to ~0.5 for the same bunch emittance of ~10pi seen in Run-3. To achieve this emittance without massively scrapping the bunches in the booster as was needed during Run-3, thinner stripping foils are being installed in the booster.

- polarization in RHIC

* going from injection to store, we typically lost ~25% of the polarization (i.e. 40%->30%).

It is believed that this loss occurred during the beta* squeeze as opposed to along the energy ramp. This opinion is based on a few ramps in which there was no beta* squeeze and no loss of polarization. The data need to be checked to see if the conclusion is completely true or whether there was also loss on the ramp.

* tune control and, maybe, orbit control

The tune control was not reliably operational until near the end of the run. When it was, it controlled the tune quite well during the ramp. Having such control will certainly improve the polarization retention. It is expected to be used regularly in Run-4.

* tune to a new working point

Putting the working point between the 3/14 (0.21) and 1/4 (0.25) spin resonances results in a more limited tune space than is available at ~0.195. So, tuning to a lower working point may benefit polarization retention. However, such a point where the machine is stable has to be identified first. Presently, they are working on simulations to locate this point. Questions which arose were:

Q: can you simulate the beam-beam tune shift effects accurately?

Absolutely, maybe not. But, relatively, is the goal. Learning that one working point is better relative to another is sufficient at this time to make progress on this matter.

Q: would having different working points per species be an issues?

Probably not.

Q: would you also tune Au-Au to the new working point if this point is found?

If there was a big gain, probably yes. However, Au-Au is not limited by beam-beam interactions, so it is unlikely that there is a big gain out there for it.

Q. would a change in the working point affect the tune feedback control (PLL) system?

Probably yes though, in principle, the system should handle it gracefully, but we would need to see how things.

(4) In a p+p commissioning run in Run-04, what would be the key items which would be pursued?

- in AGS:

* tuning for polarization with the weak snake

- in RHIC:

* understanding the beam-beam interaction by:

(A) testing new working point to have more tune space to work in
(B) improving the non-linear corrections to reduce the size of the resonances

* test of the Ng coating to control the pressure rise when pushing bunch intensities past 1e11

* 250 GeV ramp

* spin flipper commissioning

As Waldo pointed out, we have been commissioning the spin flipper on "when convenient" basis. Since the experiments do see crossing-by-crossing differences, we might consider allocating a reasonable amount of commissioning time to bring it up to an operational state.

* grow the emittance during the or end of the ramp so that lower emittance bunches can be ramped in the AGS (good for polarization) and then become higher emittance bunches when colliding in RHIC (good for luminosity)

* the polarized hydrogen jet target needs a shakedown run

(5) What is the amount of time needed to do this commissioning?

Thomas said that they would need 5 weeks (which includes the setup time) to do the necessary studies. People questioned whether this time was sufficient and whether collisions at experiments were needed to assure that what is learned from these studies would be representative of the future performance. Thomas agreed to think about how much "experiment" running would be needed on this front.

(6) What is a reasonable scenario to use as a "success" model for developing the beam-use proposal?

We had a long discussion about this matter and we'll be returning to it again when we get together in roughly 2 weeks.

Polarized Protons in Run 4 and Beyond

Issues to address

- How to reach RHIC spin 'enhanced' performance?

  P_{beam}=70% and $\int \mathcal{L}\, dt = 320(800)\ pb^{-1}$ at $\sqrt{s} = 200(500)$ GeV in a 10-week run

⇒ Need a plan for increasing $\vec{p}+\vec{p}$ luminosity from ~0.3 → ~30 pb^{-1}/week

- How to sustain momentum of RHIC spin program until performance is attained?

⇒ Require intermediate goals (*e.g.*, probe ΔG through inclusive jets, hadrons)

Scenario for RHIC spin in run 4

- Commission AGS/RHIC complex (~5 weeks)
  - o develop RHIC to make progress towards goal of ~30 pb^{-1}/week, with P_{beam}=70%
  - o commission polarized gas jet target: FY04 goal $\Delta P/P$~10% at 100 GeV
- Physics run to complete inclusive jet/hadron A_{LL} measurement (~3 weeks)
  - o contingent on $P^4 \times \mathcal{L}_{avg\ week} > 10\ nb^{-1}$ ($\mathcal{L}_{avg\ week} > 1\ pb^{-1}$ with P>30%)

STAR spin

From bunce@bnl.gov Mon Jun 30 07:12:44 2003
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Subject: RE: Monday's RHIC spin meeting

Hello Thomas--I am glad that you will be able to come to the discussion on Monday. Basically, we want to better understand your thoughts about past and future runs. The reason for the timing is to prepare for the DOE review. Also, the experiments are having discussions on their plans for run 4, and we want to develop a recommendation from the spin perspective. (I actually do not think that the review committee should weigh in on the number of species issue--this is part of the beam use proposal process. However, many of us are worried that they may.)

At our Phenix spin meeting on Friday, we tried to collect the accelerator
issues that were coming up, where we would like a better understanding.

How do we see machine development for heavy ions in past years? Did our knowledge advances/luminosity advances saturate for each run? Could we have used more development time?

Same for pp.

What are the critical points for heavy ions, Run 4? Yasuyuki's list: total current limitation of Au beam; storage rf; luminosity lifetime; other major issues for Au-Au?

What are the critical points for spin? What can be accomplished in Run 4 if we had machine development? How long should that be?

What should we use as reasonable successful scenarios for each? Is this the "maximum" scenario of your letter?

What is your view on the past approach of 2 species per run?

What is your view on future planning on length of runs and species?

Does CA-D have sufficient manpower for efficient and reliable operation of RHIC for 27 weeks a year? 37 weeks a year? 1 or 2 species?

Uptime. The reliability of RHIC is an important issue. The lack of can cut sharply into machine development efficiency as well as LxT. This was a major issue for Run 1, and I believe it is still a problem, even though it is greatly improved. What are your thoughts about this, and can we use the review to get support for improvements (such as the previous question)?

Thanks for your advice on any of these.

Gerry

RHIC Spin Collaboration Meeting XVIII
June 30, 2003
RIKEN BNL Research Center

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RHIC Spin Collaboration Meeting XVIII

June 30, 2003

Small Seminar Room, Physics Dept., Brookhaven National Laboratory

*******AGENDA*******

Open Discussion

RHIC Spin Collaboration Meeting XIX, August 18, 2003
by B. Fox and G. Bunce

Discussion of the details and importances of the R&D efforts in Run04 for the spin program.

To open the meeting, Thomas Roser commented that his recent memo on guidance for a 5 year plan did not readdress spin R&D, from an earlier memo which covered just 1 year. He and his group have done that now, and this was presented yesterday. He plans to write an official memo on to supplement his existing memos on the machine. Here is the outline of spin R&D that Thomas presented:

Below is a possible schedule for a pp R&D run for FY04. Maybe I could show this at the start of today's meeting.

Polarized jet installation at IP12	3 days
Set-up of power supplies and get first collisions	14 days
Set-up of minimum luminosity to start R&D	14 days
Beam-beam tests (new working point,...)	5 days
Polarized jet commissioning	parasitic to above
dp/p = 10% measurement with jet	7 days
Spin flipper commissioning	3 days
Tune feed-back commissioning	3 days
Total	49 days (7 weeks)

Following Thomas's presentation of this outline, Wolfram Fischer discussed the beam-beam effect which was observed in pp in 03, and their work toward defining a new "working point" (betatron tune for RHIC) which would provide more room for the beam-beam tune spread. They are using simulations to study possible tunes, and this work is in progress. Two new tunes are being considered. The large bulk of the R&D time above is for this (basically 4 weeks would be used to set up a new tune and to study it). Setting up a new tune (ramp and flattop) is described as a major effort. The goal is to find a stable tune location for both luminosity and polarization, prior to a long spin run in 05.

Next, Anatoli Zelinski described the preparations of the polarized jet target. The intensity has been measured at 4x (!) the former record for atomic beams, using 3 methods of measurement. (The result is 30% higher than predictions from simulations.) The rf transitions are now being installed, which are not expected to change the intensity, just provide polarization. Polarization is to be measured in September. In October the jet will be installed in RHIC (12 o'clock), tested, then returned to the lab. (The vacuum level precludes leaving it in place for the gold-gold run.). The design plan allows quick installation (3 days, including pump down), which will be tested in October.

The target would be commissioned parasitically with the beam-beam work. The 7 days indicated above for a polarization measurement are likely to be parasitic to, for example, experiment data-taking.

And, finally, Mei Bai discussed the spin flipper. The idea is to flip the spins in one ring, to decouple crossing dependences of our measurements from spin. Kiyoshi Tanida has shown, for example, a clear crossing dependence of the width of the longitudinal vertex distribution at Phenix which persists through the store. Ultimately, this device would buy us roughly an order of magnitude on systematic errors due to crossing effects in measuring asymmetries. (This is my estimate. Kiyoshi found that spin flipping is not needed at our present 10^-3 statistical error in raw asymmetry. Therefore, I see this as developing a potentially important tool for the longer term spin program. The device also provides a clean way to establish the settings for the Siberian Snakes.) The proposed 3 days includes studies of settings for the spin flipper (rf dipole frequency and amplitude, at injection and 100 GeV). This work had some success in the 02 run. In 03 the tests gave beam aborts from Phobos radiation monitors.

In addition, Waldo showed us a picture of the new AGS Siberian Snake (5%). It is now wound (at RIKEN in Japan). It is expected to be installed in the AGS this fall/winter. With it, the polarization improvement is expected to be 25% (that is, from 0.4 to 0.5 in the AGS. The machine group plans to commission it and develop AGS polarization in a 4 week run parasitic to the gold-gold running.

To close the meeting, we had a discussion which focused on a 5 week R&D effort to study the beam-beam effect and to commission the jet target.

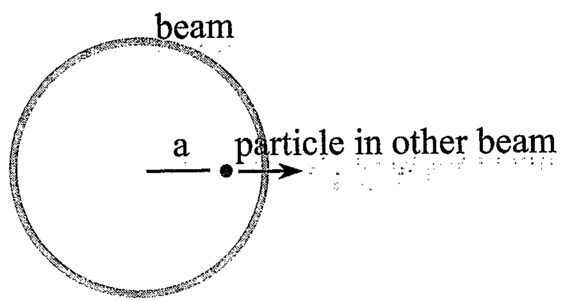
We also discussed potential physics if the figure of merit is improved from 2003 by a factor of 10 or more. (F.O.M. = P^4 x LT; stat. errors ~ sqrt F.O.M.) From polarization improvement to P=0.4 alone, the F.O.M. improves by a factor of 5. If a factor 10 improvement in F.O.M. is demonstrated from the 5 week R&D, we could then get a very exciting measurement of gluon polarization using pi^0 at PHENIX and jets at STAR, in a 1 month physics run. This measurement would also be timely, far better than COMPASS at CERN which expects to run also in 2004.

Beam-Beam Issues in RHIC

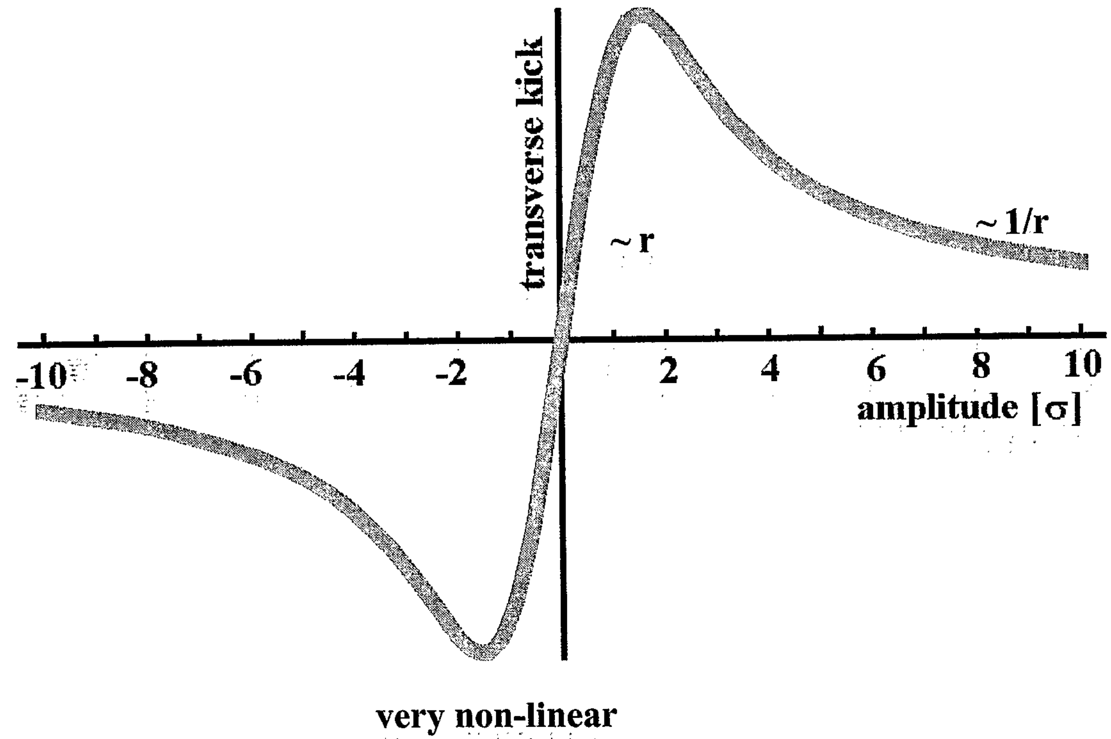
Wolfram Fischer

BROOKHAVEN
NATIONAL LABORATORY

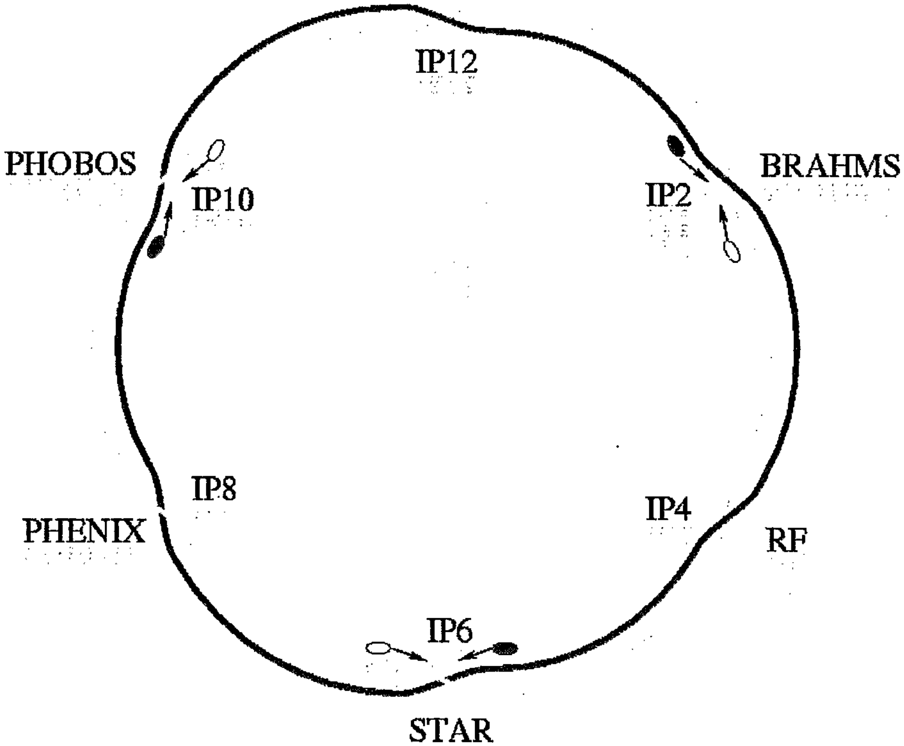
RHIC Spin Collaboration Meeting 2003
18 August 2003



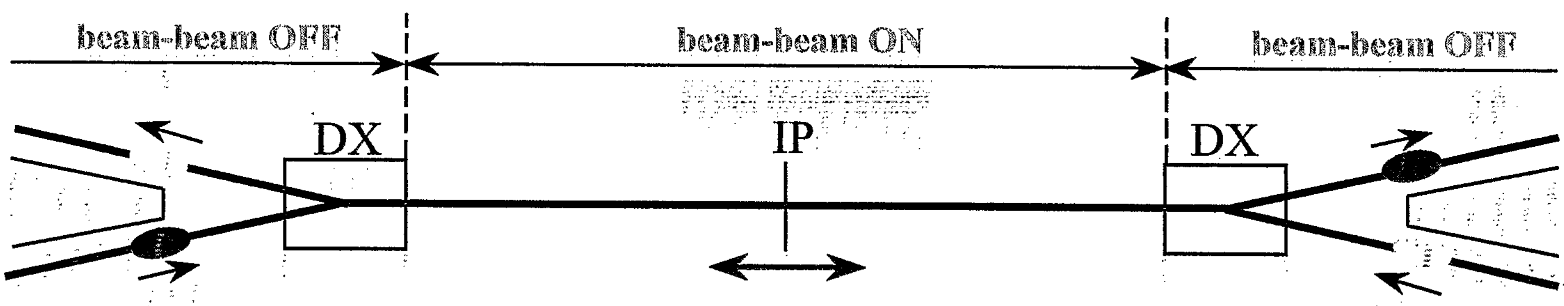
$$\Delta r' = -\frac{N_b r_0}{\gamma r}\left(1 - e^{-r^2/2\sigma^2}\right)$$



- Like magnets, other beams creates electro-magnetic forces
- Unlike magnets, other beam defocuses in BOTH planes (pp)
- Maximum tune shift for particles in beam center,
  no tune shift for particles at large amplitudes
  → BB creates transverse tune spread in beam
- With same intensities, coherent effects are possible



- Beams of comparable charges
- Two independent rings
- No parasitic collisions in stores
- Nominally no crossing angle
- Beam-beam couples 6 bunches (3 Blue and 3 Yellow)
- More complicated on ramps if rf not locked



	ISR	SPS	Tevatron Run I	HERAp	RHIC* p 2003	LHC
Bunches per beam	coasting	3	6	174	55	2808
Experiments	6	2	2	2	4	4
Parasitic interactions		4	10	—	—	120
beam-beam ξ / IP	0.001	0.009	0.008	0.0007	0.004	0.003
Total bb tune spread, max	0.008	0.028	0.024	0.0014	0.015	0.010

* Numbers assuming ε_N=15μm and N_b=0.7 10^{11}

Sources: W. Schnell PAC75, W. Herr, V. Shiltsev, C. Montag

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- Total tune spread from beam-beam in proton operation with ε_N=10μm (95%) and $N_b=10^{11}$ will be as large as the maximum achieved in any past hadron collider
- Unlike past hadron colliders (weak-strong except ISR), RHIC operates in a strong-strong regime

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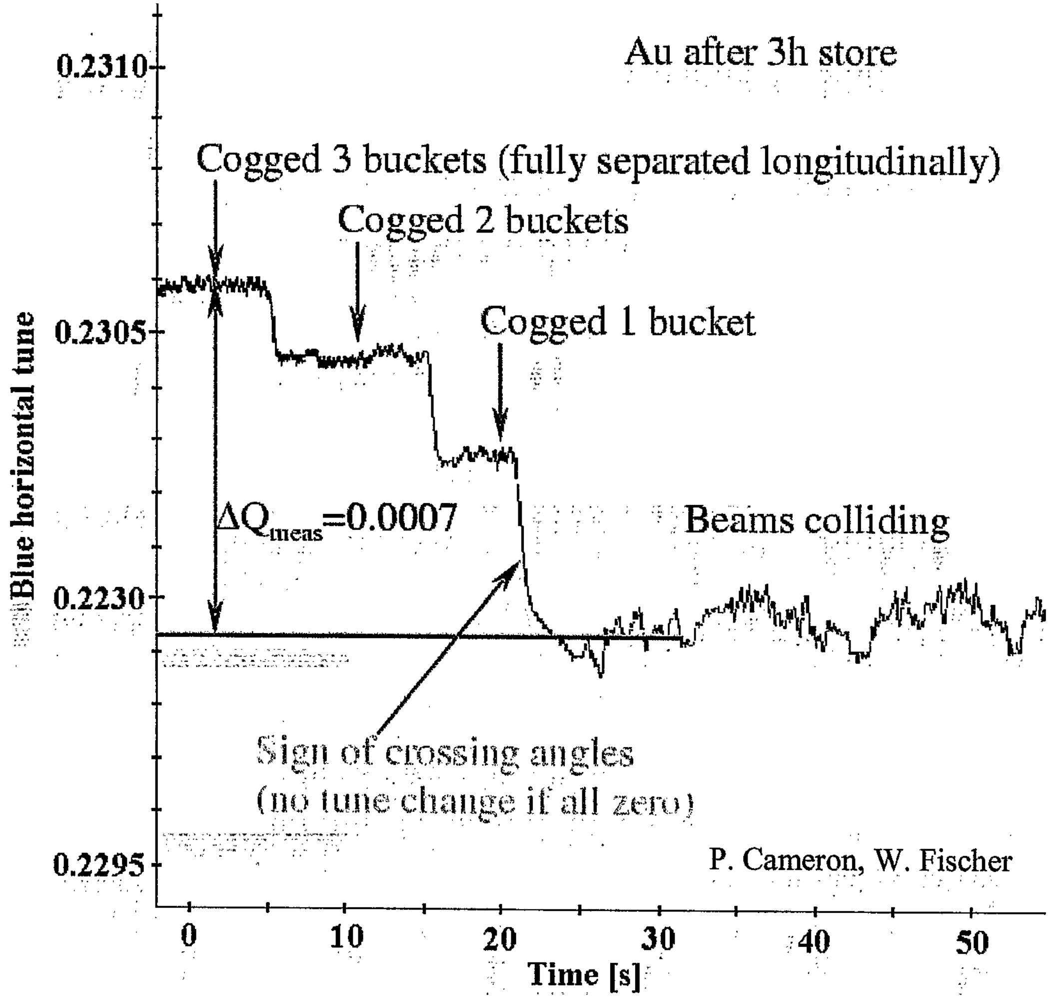
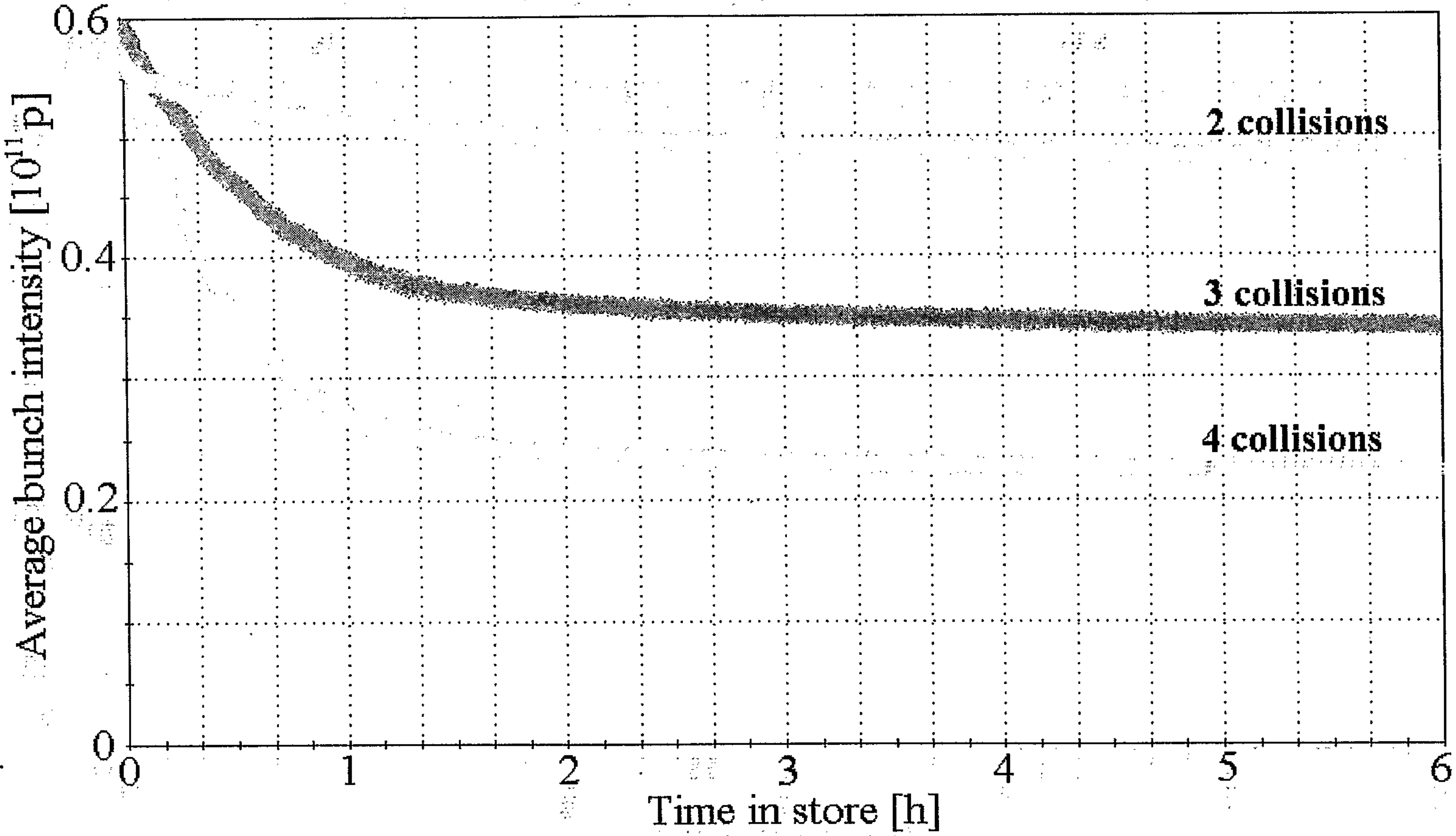
- Beam-beam parameter measured with PLL (high precision)
  $\xi \approx 2 \cdot \Delta Q_{meas}/N_{IP}$

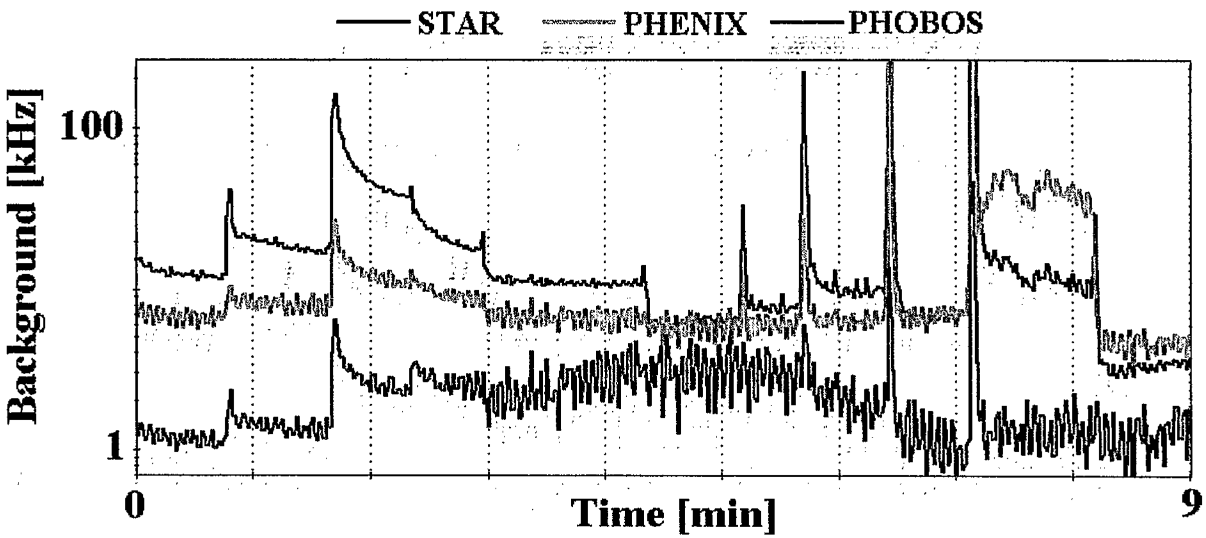
  [P. Cameron et al., BNL, "RHIC third generation PLL tune system", PAC03]
- Also shows effect of crossing angles
- Is also an emittance measurement:
  $\varepsilon_N = 1.5 N_b/\xi$,
  N_b well known



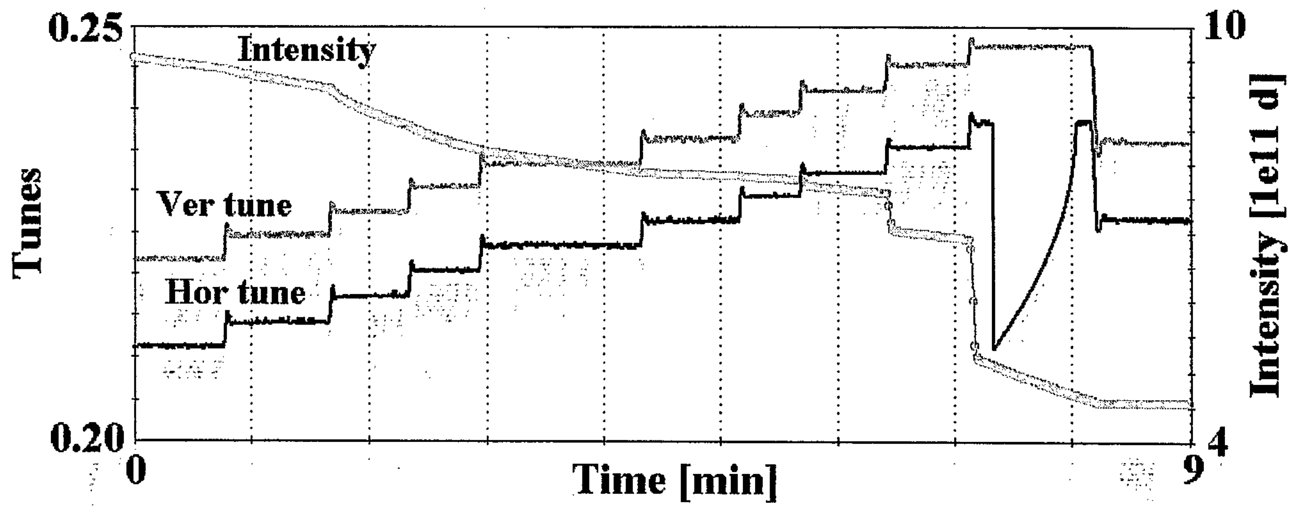
Beam lifetime with different number of collisions, ξ=0.003/IP
(due to abort gaps some bunches see only 2 or 3 collisions per turn)



Deuteron–gold collisions, ξ / IP $\approx$ 0.001, 4 head-on collisions

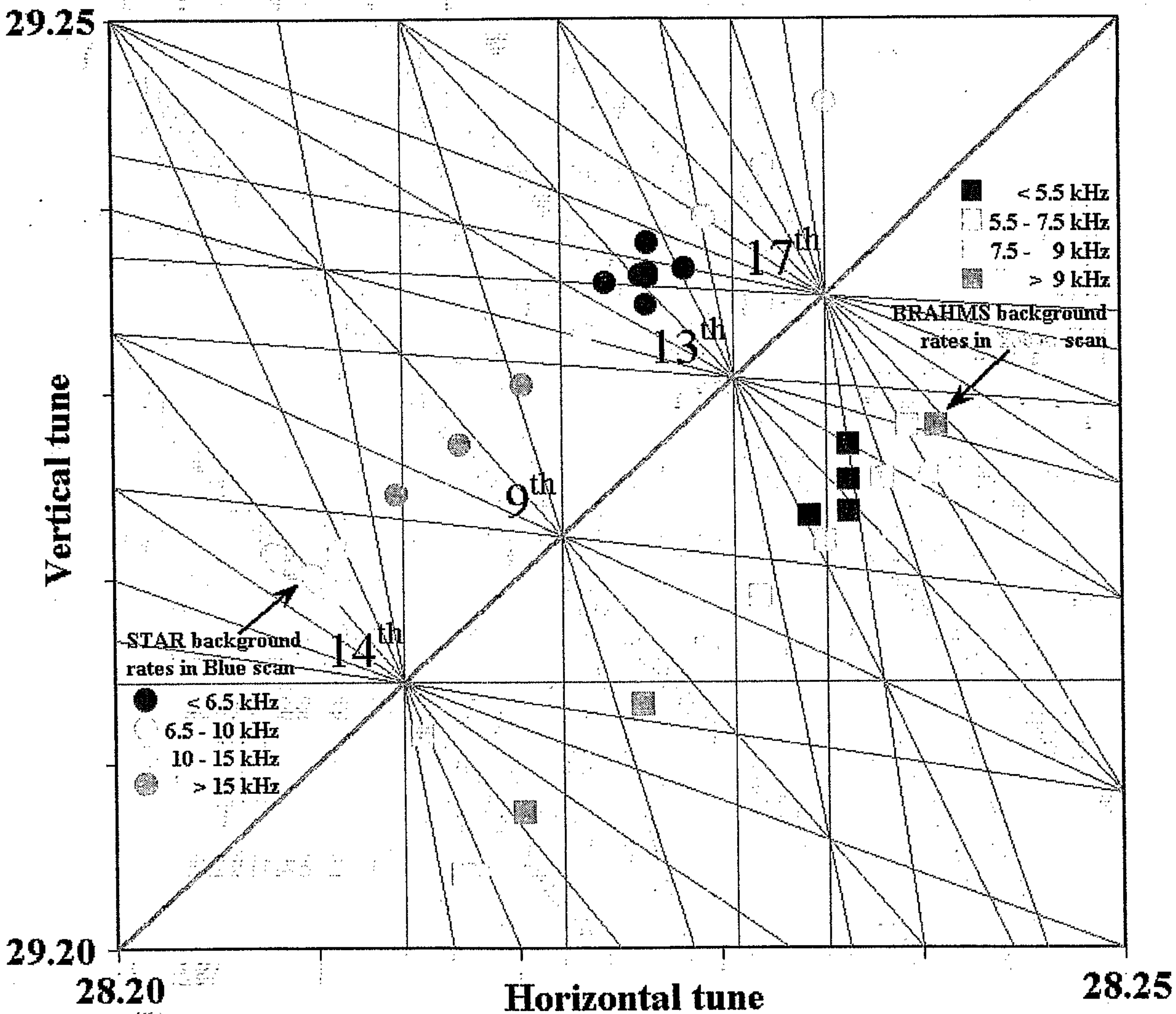


Experimental backgrounds



Tunes and beam intensity

Deuteron-gold collisions, ξ / IP $\approx$ 0.001, 4 head-on collisions



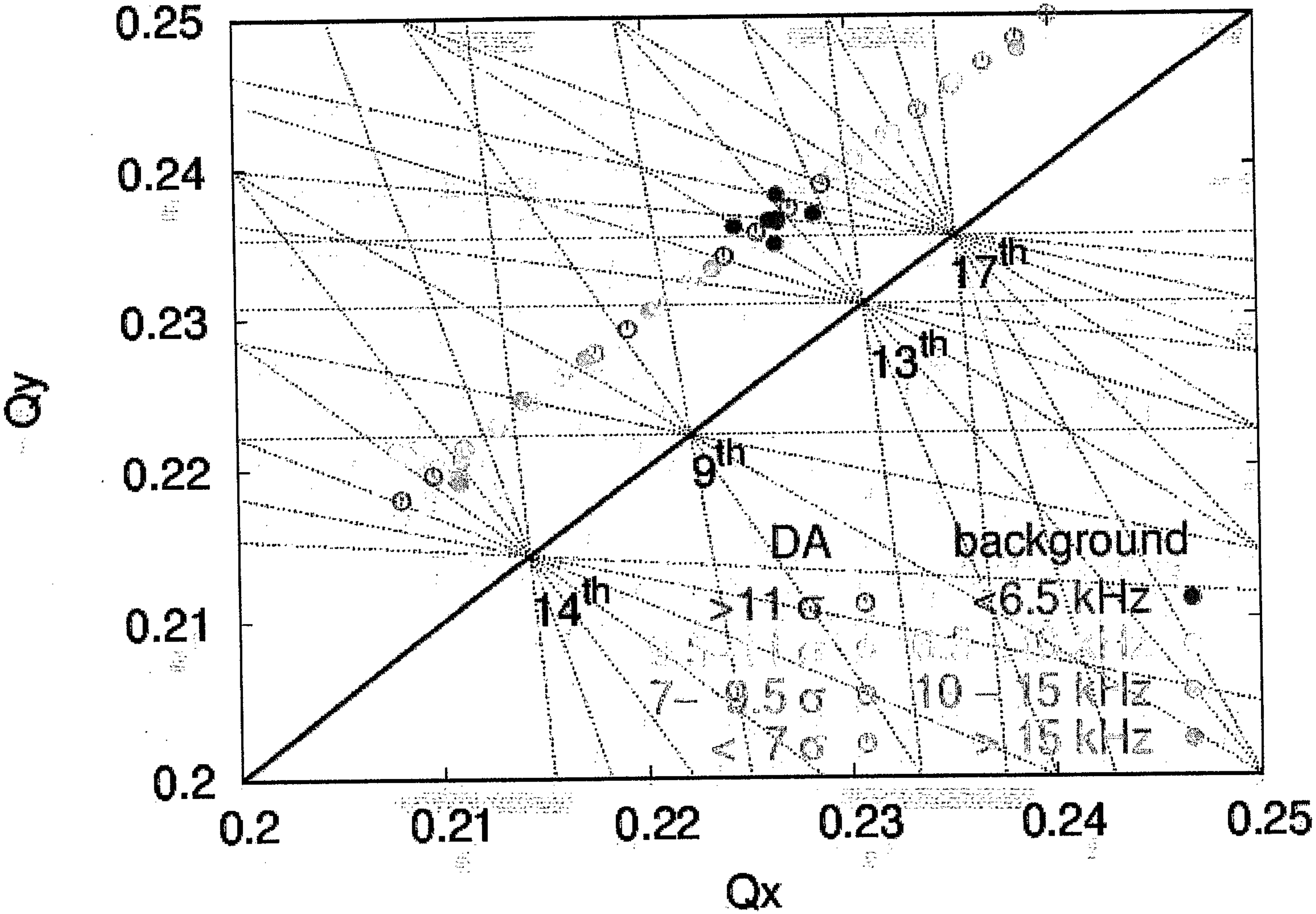
Lowest order resonances are of order 9 between 0.2 and 0.25

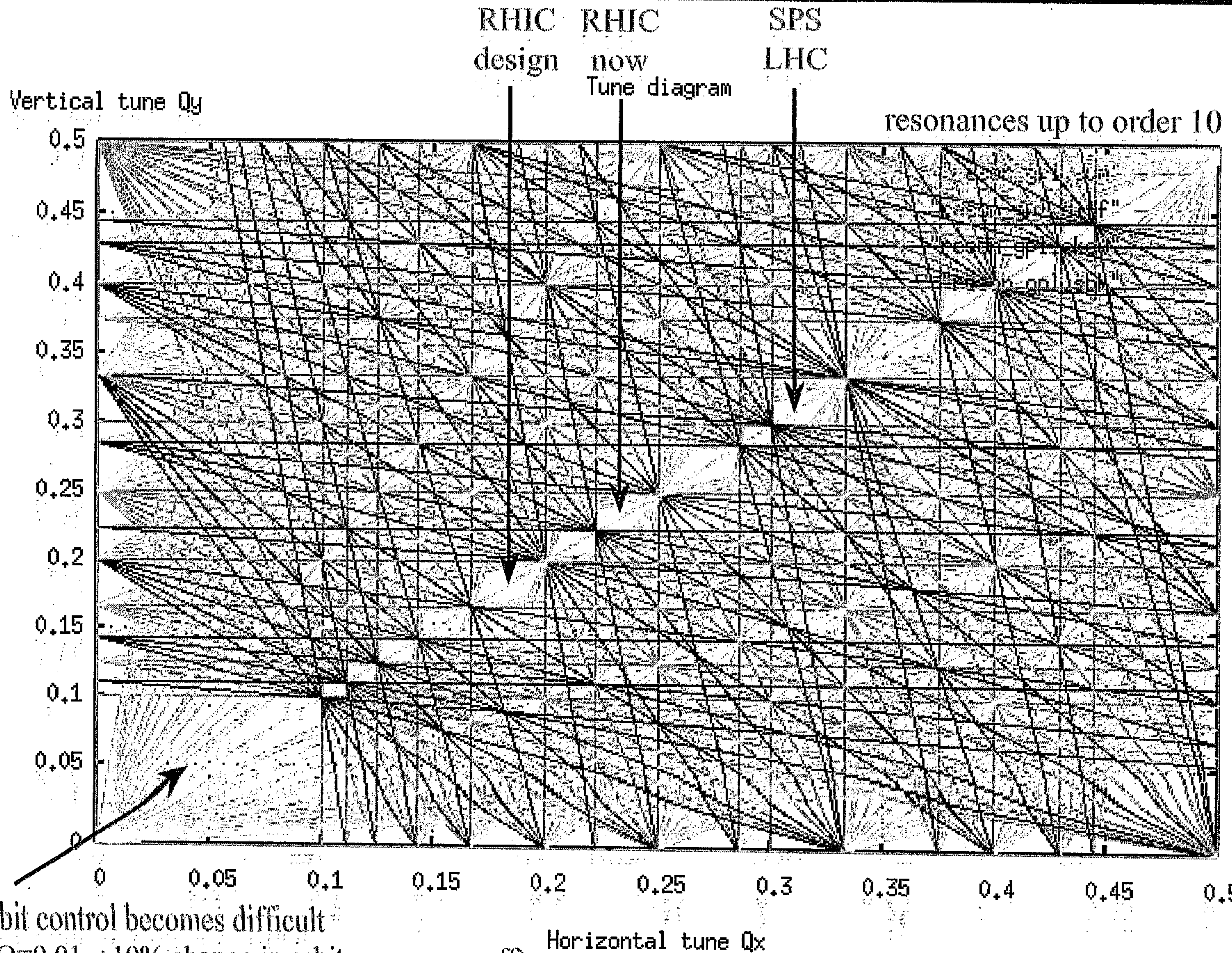
High background rates near 9th order resonances (residual crossing angles)

Low background rates near 13th order resonances (used in operation)

- If IRs are well corrected, beam-beam effect dominates beam and luminosity lifetime
- Choice of working point is the main decision
  - Need to avoid resonances of order 10 and lower
- Simulations (Rogelio Tomas):
  - Reproduce existing observations
  - Test new working points
- Working points under consideration:
  LHC (SPS), Tevatron, ISR, RHIC (design)
- WP needs to be compatible with spin dynamics
- Currently LHC and RHIC design are best candidates for new working point

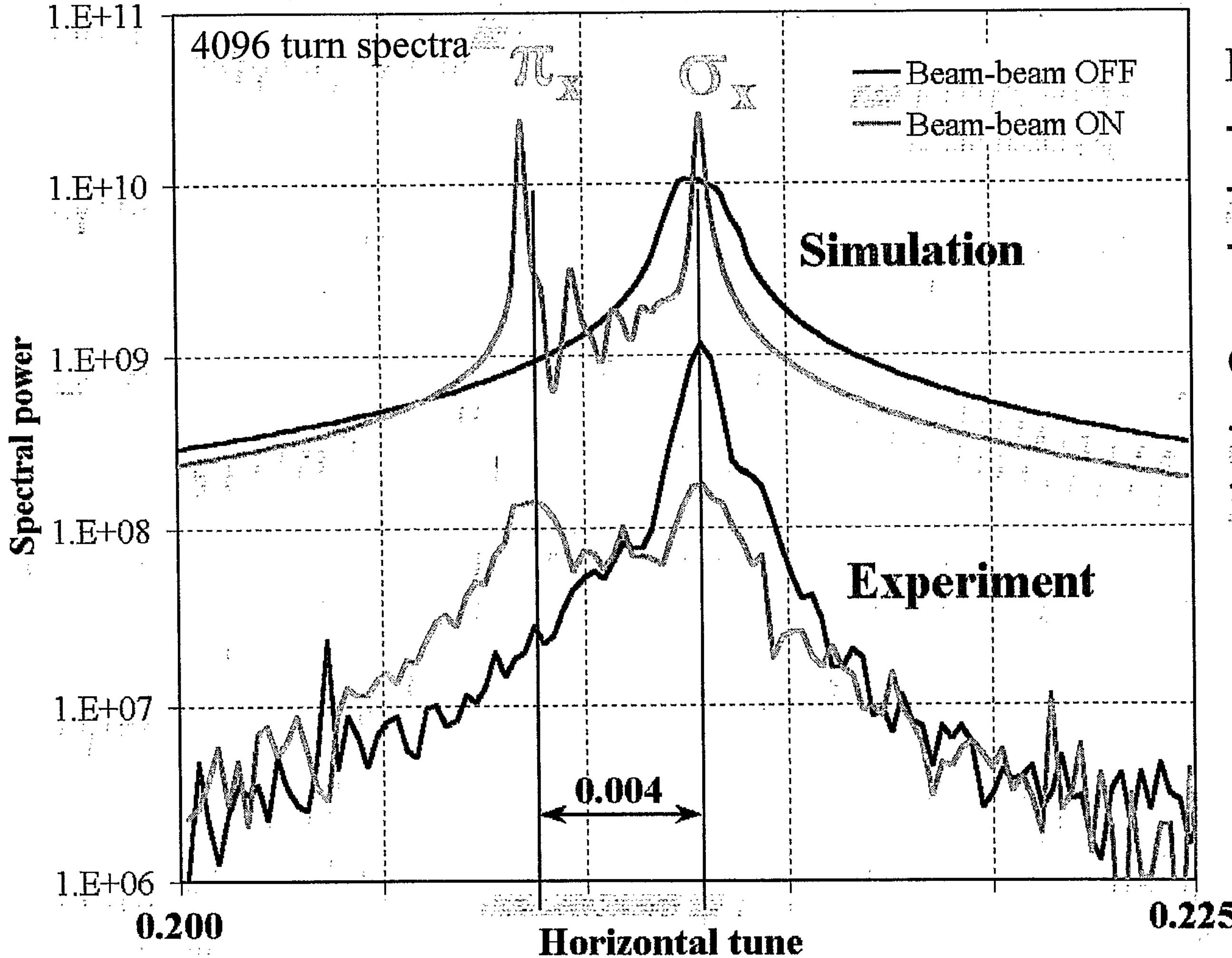
So far insufficient agreement between observations and simulations





Orbit control becomes difficult
($\Delta Q=0.01 \rightarrow 10\%$ change in orbit response coeff)

1st π-mode observation in hadron machine, no problem in operation so far



Experiment:
- single p bunch/ring
- **$\xi = 0.003$**
- $|Q_{x,B} - Q_{x,Y}| < 0.001$

Observation:
- π_x-mode shift: 0.004
- expectation:

$$1.21 \cdot \xi = 0.0036$$

[Yokoya, Meller, Siemann]

[Simulation: M. Vogt et al., DESY, "Simulations of coherent beam-beam modes at RHIC", EPAC02]

- Beam-beam interaction is an important consideration in the operation of RHIC
  - → Dominates beam lifetime with pp ($\tau \approx$15 hrs)
  - → Increases transverse emittance ($\Delta\varepsilon/\varepsilon \approx$ 4% in 1st hr)
  - → Leads to increased background (near 9th order resonances)
- Main choice to deal with beam-beam is the working point
  - → Working on simulations to reproduce observations (Rogelio Tomas)
  - → Consider new working points
  - → Working points need to be compatible with spin dynamics
- Strong-strong effects not yet a problem in operation

Polarized Jet Target Status and Plans 08/18/03

A.Zelenski, Y.Makdisi

Past two weeks in the jet Lab:

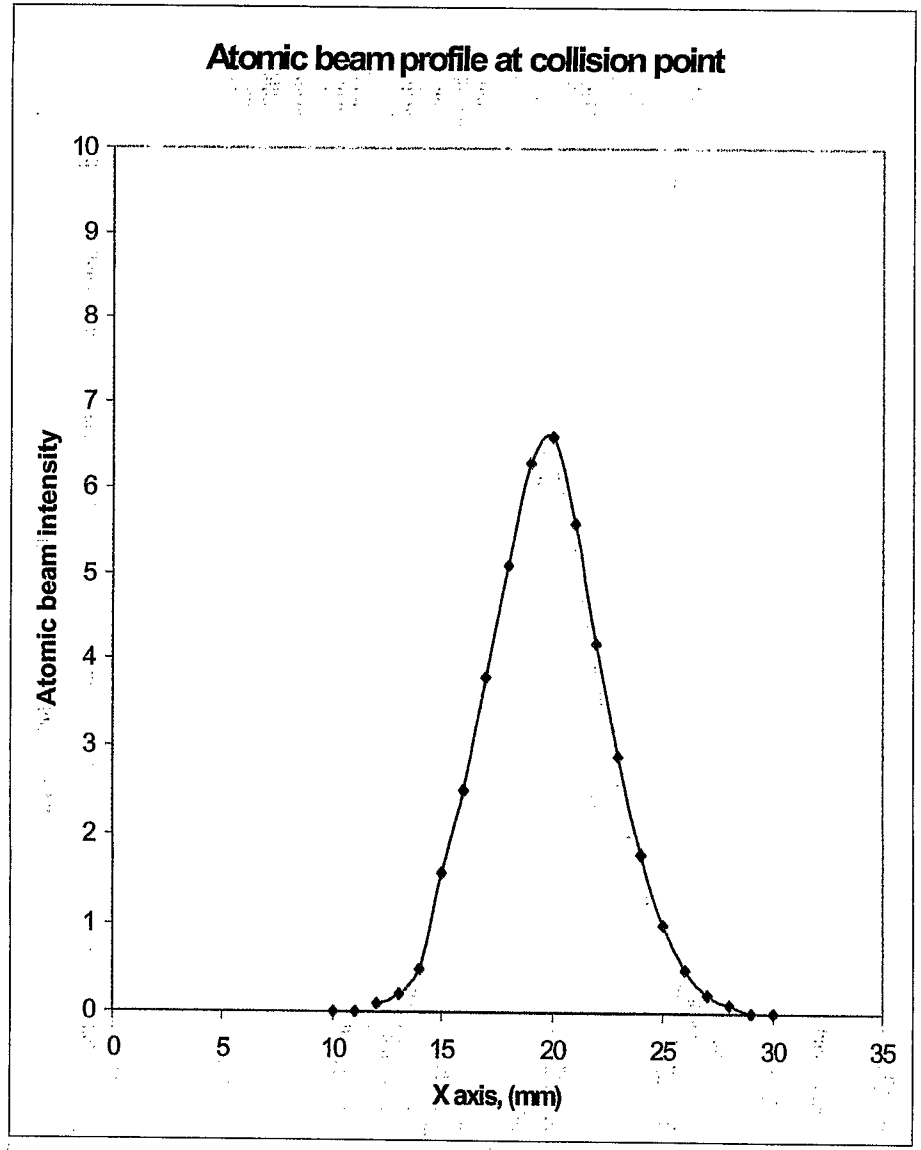
- Studied the dissociator performance and atomic beam transmission at the collision point.
- Measured record beam intensities 12.4 x 10^{16} atoms /sec
- Measured the beam profile at the -5 cm, IP +5 cm to be 5, 5.5, 8 mm respectively w/o correction to slit size.
- The beam seems to be centered to within 1 mm.
- Re measure the magnet to assure adiabatic conditions and zero crossings at the desired locations.
- Prepare the BRP rf transitions, and support structures.

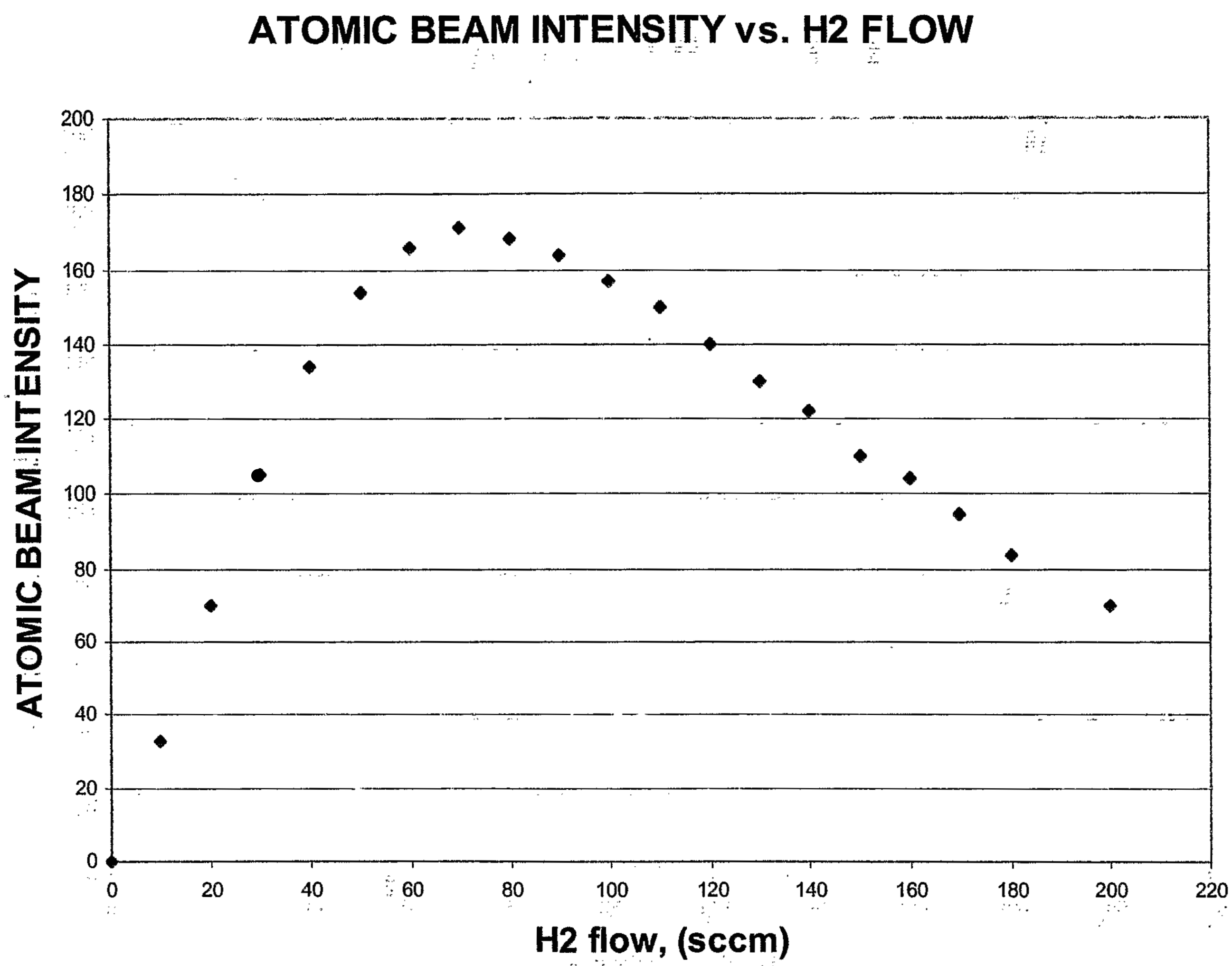
Atomic beam profile at the collision point

- Atomic beam profile was measured with a 2.0 mm in diameter compression tube FWHM=5.0 mm

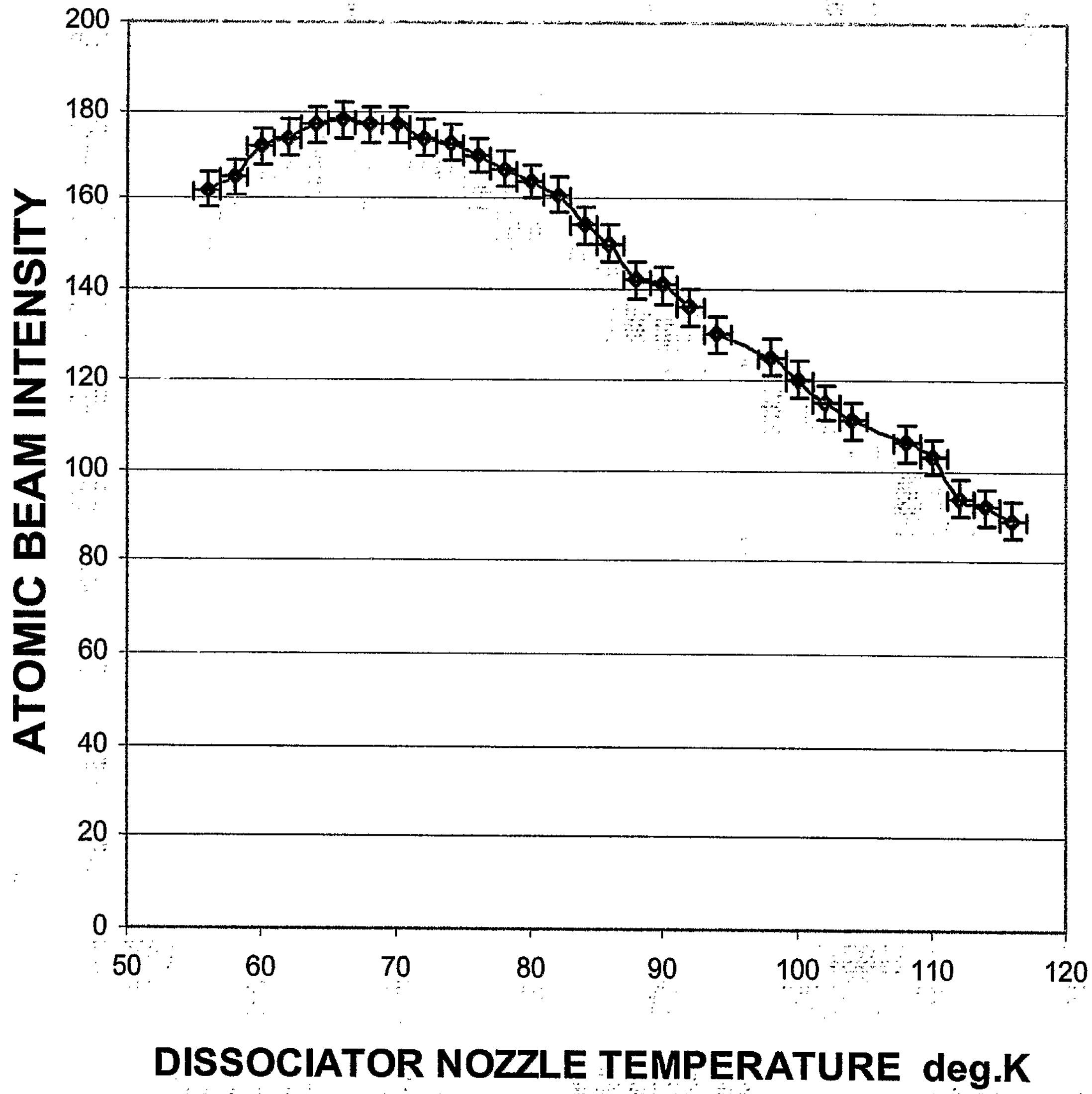
- 5 cm upstream the beam profile FWHM is about 4.5mm and 120 mm downstream FWHM is about 7.0 mm

- In assumption, that beam velocity is $2 \cdot 10^5$ cm/s, the H - jet thickness at the collision point is about $2 \cdot 10^{12}$ atoms/cm^2.




ATOMIC BEAM INTENSITY vs. H2 FLOW
ATOMIC BEAM INTENSITY
H2 flow, (sccm)
0
20
40
60
80
100
120
140
160
180
200
220

ATOMIC BEAM INTENSITY vs. DISSOCIATOR NOZZLE TEMPERATURE



The upcoming tasks

The next two weeks:

- Install the RF transitions in the ABS stage
- Install the magnet and the scattering chamber
- Install the BRP stage.
- Complete the wiring of the PLC and test system interlocks. Allows uninterrupted running the of the pumps and dissociator to test long term stability.
- The target completion date for hardware installation is the end of August.

Work in the IR

- Electrical work continues. The hut is wired. The AC unit installed. The transformer is installed and wiring to the rack disconnect is in progress. Completion next week.
- Two 16 inch pipe penetrations into the IR for cables are in. Core drilling on the inside and sealing will be completed mid next week.
- The cable tray mounting to take two weeks. Start with the inside tray.
- The majority of the cables are in hand and cable pulling will be scheduled soon after.
- The tunnel entrance doors modifications are complete.
- The IR crane design is settled. Procurement to follow.
- Still working on the magnet cooling options (50 kW).

Timeline and plan

September 2003

- Run the jet in the lab.
- Measure the jet intensity and beam polarization
- Run the jet under system control and interlock
- Prepare the jet assembly for the move to the RHIC ring.
- Finalize moving plan with the riggers.
- Complete the preparations in the IR. The crane, the tracks, and cable trimming.

October 2003

- Move the jet to the IR.
- Assess how long it takes to get the jet up and running
- Run the jet and study performance with remote control.
- Move the jet back to the lab at the end of the month.

RHIC Spin Flipper

RHIC Spin Collaboration Meeting, August 18, 2003

Mei Bai, BNL, Upton, NY 11973

Spin flipping during RHIC pp 2003 in Blue ring

Fill #	Drive amp.	$\Delta\nu_d$	Δt [turn]	ν_s	P_{b0}	P_{b1}	P_{b2}	P_{y0}	P_{y1}
3799	0.26	0.47-0.49	2×10^6	0.48	0.22	0.20	-0.054	0.24	0.068
3801	0.3	0.47-0,49	2×10^6	0.48	0.234	0.224	0.0223	0.23	0.065
3803	0.8	0.46-0.48	2×10^6	0.47	0.18	-0.049	N/A	0.21	0.23
3811	0.4	0.465-0.485	2×10^6	0.475	0.076	0.0	N/A	N/A	N/A

What can we learn?

- Spin tune in yellow is not 0.5
- Need time to calibrate snake setting – spin tune measurement
- Simulation is needed to study the spin tune spread effect
  - Source for spin tune spread
    - Beam emittance: ~ 0.009(15π, 100GeV)
    - Higher order effects: needs tracking to find out
- The last two spin flipping attempts with stronger spin flipper strength caused the radiation level around phobos exceeded the threshold limit which pulled the permit.
  - No aperture at the end of store to do the spin flip study.
  - Prefer to have dedicated time to commission the spin flipper

Spin flipper commissioning plan

- spin tune measurement

  method: measure the polarization vs. different spin flipper frequency
  - at injection: 8hr
    - two sets of 10 datapoints, each data point is taken with new filled bunches(55, filling time=5min) and each datapoint takes 5min to measure.
  - at store: 16hr
    - two sets of 10 datapoints. the same assumption as the injection measurements plus the ramping timing and new stores if necessary.

  The amount of time for this measurement can be greatly reduced if one can measure the turn-by-turn spin precession.

Spin flipper commissioning plan

- spin flipping

Three sets of measurements:

a) measure the spin flipping efficiency vs. flipper strength. The flipper frequency sweep range as well as the spin tune remain constant.

b) measure the spin flipping efficiency vs. flipper frequency sweep range with fixed flipper strength as well as the spin tune.

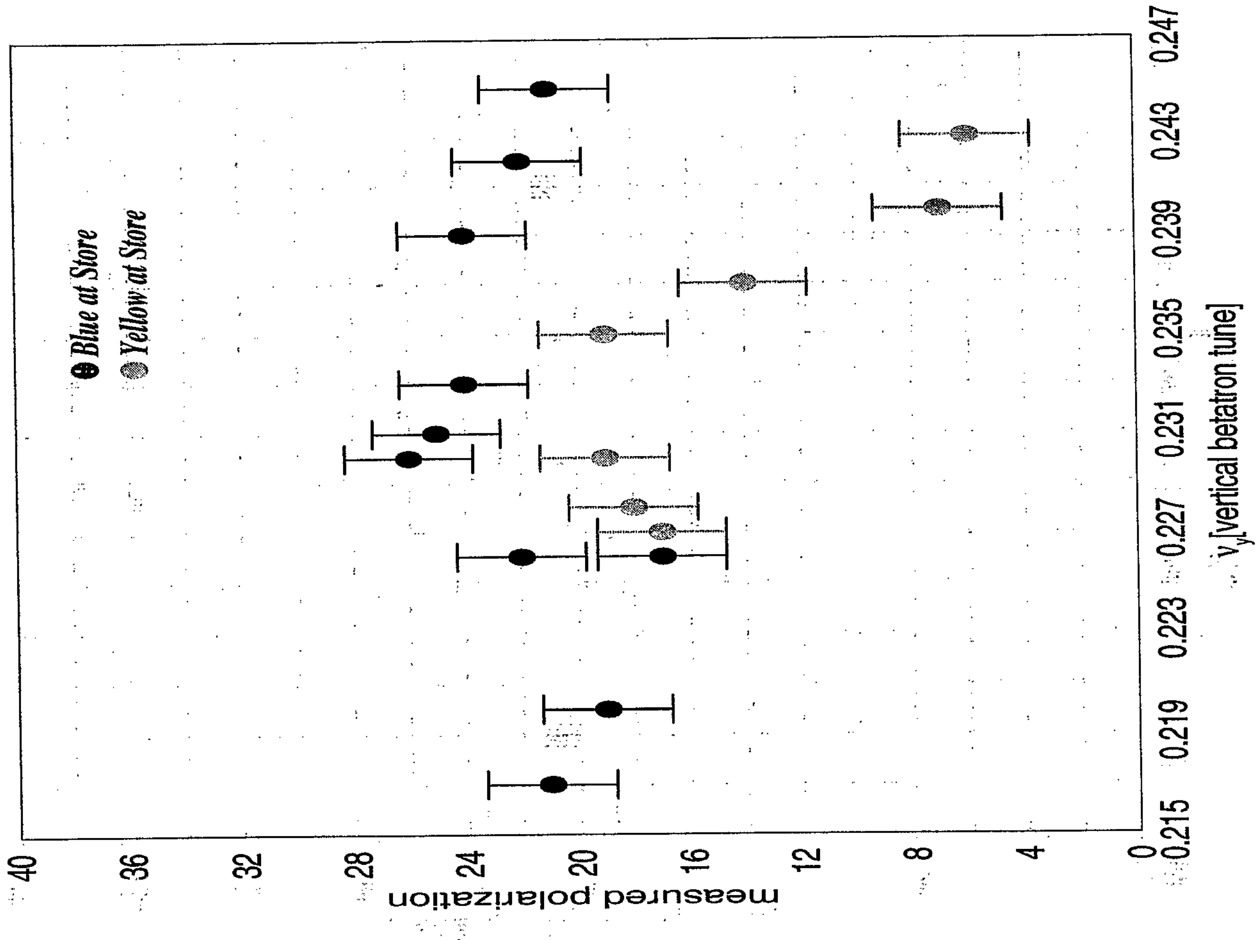
c) repeat b) with different spin tune.

with the current snake power supplies, we are able to move the spin tune to 0.45 the outer current of one snake should be 94Amps and the inner current should be 294.54Amps. The nominal current setting for the snake is (inner,outer)=(326.23,100). It takes about 2 minutes to ramp the snake current from 326.23 to 294.54.

Spin flipper commissioning plan

Prefer to do the measurements at injection first. The estimate for the three measurements is 16hrs. To do a) and b) at store, one may need about 20 stores (assume 10 data points per set). Assume 50 mins per store including the measurement, total 16 hrs will be needed.

Spin tune at store



p-p R&D Run During FY2004

T. Roser, BNL
August 18, 2003

for
RHIC Spin Collaboration Meeting XIX
RIKEN BNL Research Center

p-p R&D run during FY2004

Pol. Jet installation	3 days
Set-up of power supplies and get first collisions	14 days
Set-up of minimum luminosity to start R&D	14 days
Beam-beam tests (new working point, ...)	5 days
Pol. jet commissioning	parasitic to above
dp/p = 10% measurement with jet	7 days
Spin flipper commissioning	3 days
Tune feed-back commissioning	3 days
Total	49 days
	7 weeks

BROOKHAVEN
NATIONAL LABORATORY

RHIC Spin Collaboration Meeting XIX
August 18, 2003
RIKEN BNL Research Center

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RIKEN BNL Research Center

RHIC Spin Collaboration Meeting XIX

August 18, 2003

Small Seminar Room, Physics Dept., Brookhaven National Laboratory

*****AGENDA*****

2:00 – 2:30	Beam-Beam Issues in RHIC..	W. Fischer
2:30 – 2:45	Polarized Jet Target Status and Plans....................................	A. Zelinski
2:45 – 3:00	RHIC Spin Flipper..	M. Bai
3:00 – 3:10	Coffee Break	
3:10 – 5:00	Discussion, Run-4 and Beyond	
	p-p R&D run during FY2004...	T. Roser

Additional RIKEN BNL Research Center Proceedings:

Volume 54 – RHIC Spin Collaboration Meetings XVII, XVIII, XIX – BNL-
Volume 53 – Collective Flow and QGP Properties – BNL-
Volume 52 – RIKEN School on QCD "Topics on the Proton" – BNL-71694-2003
Volume 51 – RHIC Spin Collaboration Meetings XV, XVI – BNL-71539-2003
Volume 50 – High Performance Computing with QCDOC and BlueGene – BNL-71147-2003
Volume 49 – RBRC Scientific Review Committee Meeting – BNL-52679
Volume 48 – RHIC Spin Collaboration Meeting XIV – BNL-71300-2003
Volume 47 – RHIC Spin Collaboration Meetings XII, XIII – BNL-71118-2003
Volume 46 – Large-Scale Computations in Nuclear Physics using the QCDOC – BNL-52678
Volume 45 – Summer Program: Current and Future Directions at RHIC – BNL-71035
Volume 44 – RHIC Spin Collaboration Meetings VIII, IX, X, XI – BNL-71117-2003
Volume 43 – RIKEN Winter School – Quark-Gluon Structure of the Nucleon and QCD – BNL-52672
Volume 42 – Baryon Dynamics at RHIC – BNL-52669
Volume 41 – Hadron Structure from Lattice QCD – BNL-52674
Volume 40 – Theory Studies for RHIC-Spin – BNL-52662
Volume 39 – RHIC Spin Collaboration Meeting VII – BNL-52659
Volume 38 – RBRC Scientific Review Committee Meeting – BNL-52649
Volume 37 – RHIC Spin Collaboration Meeting VI (Part 2) – BNL-52660
Volume 36 – RHIC Spin Collaboration Meeting VI – BNL-52642
Volume 35 – RIKEN Winter School – Quarks, Hadrons and Nuclei – QCD Hard Processes and the Nucleon Spin – BNL-52643
Volume 34 – High Energy QCD: Beyond the Pomeron – BNL-52641
Volume 33 – Spin Physics at RHIC in Year-1 and Beyond – BNL-52635
Volume 32 – RHIC Spin Physics V – BNL-52628
Volume 31 – RHIC Spin Physics III & IV Polarized Partons at High Q^2 Region – BNL-52617
Volume 30 – RBRC Scientific Review Committee Meeting – BNL-52603
Volume 29 – Future Transversity Measurements – BNL-52612
Volume 28 – Equilibrium & Non-Equilibrium Aspects of Hot, Dense QCD – BNL-52613
Volume 27 – Predictions and Uncertainties for RHIC Spin Physics & Event Generator for RHIC Spin Physics III – Towards Precision Spin Physics at RHIC – BNL-52596
Volume 26 – Circum-Pan-Pacific RIKEN Symposium on High Energy Spin Physics – BNL-52588
Volume 25 – RHIC Spin – BNL-52581
Volume 24 – Physics Society of Japan Biannual Meeting Symposium on QCD Physics at RIKEN BNL Research Center – BNL-52578
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Volume 19 – Numerical Algorithms at Non-Zero Chemical Potential – BNL-52573
Volume 18 – Event Generator for RHIC Spin Physics – BNL-52571
Volume 17 – Hard Parton Physics in High-Energy Nuclear Collisions – BNL-52574
Volume 16 – RIKEN Winter School - Structure of Hadrons - Introduction to QCD Hard Processes – BNL-52569
Volume 15 – QCD Phase Transitions – BNL-52561
Volume 14 – Quantum Fields In and Out of Equilibrium – BNL-52560
Volume 13 – Physics of the 1 Teraflop RIKEN-BNL-Columbia QCD Project First Anniversary Celebration – BNL-66299
Volume 12 – Quarkonium Production in Relativistic Nuclear Collisions – BNL-52559
Volume 11 – Event Generator for RHIC Spin Physics – BNL-66116
Volume 10 – Physics of Polarimetry at RHIC – BNL-65926
Volume 9 – High Density Matter in AGS, SPS and RHIC Collisions – BNL-65762
Volume 8 – Fermion Frontiers in Vector Lattice Gauge Theories – BNL-65634
Volume 7 – RHIC Spin Physics – BNL-65615
Volume 6 – Quarks and Gluons in the Nucleon – BNL-65234
Volume 5 – Color Superconductivity, Instantons and Parity (Non?)-Conservation at High Baryon Density – BNL-65105
Volume 4 – Inauguration Ceremony, September 22 and Non -Equilibrium Many Body Dynamics – BNL-64912
Volume 3 – Hadron Spin-Flip at RHIC Energies – BNL-64724
Volume 2 – Perturbative QCD as a Probe of Hadron Structure – BNL-64723
Volume 1 – Open Standards for Cascade Models for RHIC – BNL-64722